THE NUTRITION OF THE INFANT

THE NUTRITION OF THE INFANT

BY

RALPH VINCENT, M.D.

Member of the Royal College of Physicians
Physician to the Infants' Hospital: Late Senior Resident Medical Officer, Queen Charlotte's Lying-in Hospital

NEW YORK
WILLIAM WOOD & COMPANY
MDCCCCIV

TO

THOMAS MORGAN ROTCH, M.D.,

PROFESSOR OF THE DISEASES OF CHILDREN, HARVARD UNIVERSITY;
PHYSICIAN TO THE INFANTS' HOSPITAL, BOSTON;
CONSULTING PHYSICIAN TO THE INFANTS' HOSPITAL, LONDON,

IN GRATEFUL ACKNOWLEDGMENT OF HIS SPLENDID
ACHIEVEMENTS, THIS WORK IS

Dedicated

BY THE AUTHOR

PREFACE

In his endeavour to make his practice as exact and scientific as possible, the author was at one time greatly discouraged by the fact that infant feeding apparently presented almost insuperable obstacles to its rational management in health, and to exact diagnosis and treatment in the presence of disorder. While this applied, to some extent, to the management of breast feeding, it applied with greater force to substitute feeding.

In hospital and private practice he was only too familiar with the various attempts to meet the requirements, and had frequent opportunities of testing the results of practically every method at all commonly used.

But there were many failures, and, what was even more unsatisfactory, the 'successes' were achieved by means so essentially empirical that they taught no lesson for the future. It must be confessed that others were satisfied where the author was greatly discontent. For it was said to be unreasonable to expect that 'artificial feeding' should be so conducted that its results could be at all comparable with those of breast feeding. This attitude seemed to be the more serious in view of the number of women unable or unwilling to nurse their infants.

It was under these circumstances that the author turned to the work of Dr. T. M. Rotch, of Boston. Realizing the essential imperfections of the arbitrary methods of adapting cow's milk to infants' requirements, he propounded a system by which the conditions of the natural

food might be most closely approached, and by which the regulation of the food mixtures could be adjusted to the varying requirements of health and disease.

Undoubtedly the percentage method is, in some respects, more complicated than any other. It demands of him who uses it a knowledge of his materials, careful diagnosis, and the exact use of an instrument of precision. But the complexity is not greater than the facts demand, while in actual practice the method is far simpler than any other.

This method was thoroughly tested by the author in numerous cases, with the most gratifying results to all concerned, and he cannot now pretend to be in any doubt as to the value of the milk laboratory in relation to infant feeding. Its use has converted the most unsatisfactory part of his practice into one most satisfactory and full of interest.

In regard to the composition of human milk, special attention has been drawn to the factors of importance in relation to variations in nursing women and to substitute feeding.

Sufficient attention has not yet been given to the nitrogenous extractives, which probably play an important part. On this subject much work remains to be done.

Pathological lactation, so far as it is of clinical interest, also needs to be more closely studied. At present the tendency is to ascribe to the fault of the infant disorders due to the character of the milk supplied by its mother.

The provision of pure milk and the perfection of laboratory methods are essential to success, and special attention has been devoted to the details connected with the procuring and modifying of milk.

The chapters dealing with artificial feeding and with the condition of the general milk-supply summarize facts which illustrate the divorce that seems to exist between our present system of government and those practical

politics directly concerned with the health and welfare of the community.

The mortality and disease at present associated with infant life are matters of the gravest concern, and call for drastic measures. In the last chapter the facts indicating the nature of the present situation are discussed.

It would be impossible for any writer to deal adequately with the subject of infant nutrition without frequent reference to 'Pediatrics,' the work of Dr. Rotch. To him and to his publishers, Messrs. Lippincott, the author is greatly indebted for their kind permission to reproduce numerous tables, which are separately acknowledged in the text. He also desires to acknowledge the courtesy of Dr. A. H. Carter and Mr. H. Droop Richmond in permitting him to make use of their work, and of the various Medical Officers of Health referred to in the last chapter, in providing him so readily with the desired information.

1, HARLEY STREET, LONDON, W.,
November, 1903.

CONTENTS

CHAPTER I

HUMAN MILK

CHAPTER II

LACTATION

CHAPTER III

COW'S MILK

CHAPTER IV

SUBSTITUTE FEEDING—PREMATURE INFANTS —THE DIET OF LATER INFANCY

CHAPTER V

ARTIFICIAL FEEDING

CHAPTER X

THE CHEMISTRY OF INFANTILE DIGESTION

CHAPTER XI

THE DIET OF THE INFANT IN RELATION TO GROWTH AND HEALTH

CHAPTER XII

THE NORMAL DEVELOPMENT AND GENERAL EXAMINATION OF THE INFANT

CHAPTER XIII

GASTRIC AND INTESTINAL DISORDER

CHAPTER XIV

INANITION—MALNUTRITION—MARASMUS

CHAPTER XV

RACHITIS

CHAPTER XVI

SCORBUTUS

CHAPTER XVII

THE MORTALITY AND DISEASE OCCURRING IN INFANTS

ILLUSTRATIONS

TABLES

THE

NUTRITION OF THE INFANT

CHAPTER I

HUMAN MILK

HUMAN milk is a secretion of the mammary glands physiologically occurring at the beginning of the puerperium, and lasting for a period of about twelve months, its precise duration being, however, dependent on a variety of circumstances. The physical characters of milk are peculiar; it is an emulsion, and at the same time a fluid holding solids in solution. The fat it contains is suspended as an emulsion in the liquid, so that when milk is kept in a vessel for some time the globules of fat rise to the surface.

Colostrum.—At the beginning of lactation the secretion of the mammary gland consists of a fluid distinctive in its character, and materially differing from normal milk. It is of denser consistence, yellowish in colour, somewhat turbid, and of a specific gravity varying between 1045 and 1065; its reaction is alkaline. It is generally distinguished in its composition by a comparatively low percentage of fat and a high percentage of proteid. Microscopically the fluid is found to contain fat globules (which are generally smaller and less perfectly formed than those of milk), leucocytes, some of which are in a condition

of fatty degeneration, and bodies known as colostrum corpuscles.

Characters of Colostrum.—These bodies are 10 μ to 20 μ in diameter. Their protoplasm contains large and small granules, which give the proteid reactions, and do not stain with acid, basic, or neutral dyes. Certain of the granules containing fat stain with osmic acid, but these are not present in large amount. Czerny describes these colostrum corpuscles as lymphoid cells, whose function is to absorb and reconstruct unused milk globules, and to carry them from the milk glands into the lymph channels.

Colostrum disappears as soon as normal lactation is established, or soon after. Occasional colostrum corpuscles may be present in the milk for the first fortnight.

Harrington analyzed five specimens of human colostrum, and the results are shown in the table below.

CHEMICAL COMPOSITION OF COLOSTRUM.

	I.	II.	III.	IV.	V.
Fat	1·40	0·68	2·40	5·73	4·40
Milk-sugar and proteids	9·44	11·53	11·15	10·69	11·27
Ash	0·17	0·31	0·25	0·16	0·21
Total solids	11·01	12·52	13·80	16·58	15·88
Water	88·99	87·48	86·20	83·42	84·12
	100·00	100·00	100·00	100·00	100·00

Woodward analyzed the milk of six women during the colostrum period, using in each instance the total amount of the middle milk for the twenty hours. His conclusions were that colostrum corpuscles were not invariably present, that when they are present the percentage of proteids is higher, and that with the disappearance of the colostrum corpuscles the proteid percentage falls.

AVERAGE COMPOSITION OF COLOSTRUM.

		General Average of Twenty-six Analyses.
Colour - -	Yellowish - - - -	—
Reaction - -	Alkaline - - -	—
Specific gravity -	1024 to 1034 - - -	1029·5
Fat - - -	2·0 to 5·3 per cent. -	4·0 per cent.
Proteids - -	1·64 to 2·22 ,, -	1·9 ,,
Ash - - -	0·14 to 0·42 ,, -	0·2 ,,
Total solids -	10·18 to 13·65 ,, -	12·5 ,,
Lactose - -	5·6 to 7·4 ,, -	6·5 ,,
Water - -	- - - - -	87·5 ,,

These figures seem to indicate rather the character of milk in the colostrum period. After a few days the colostrum generally practically disappears. The pure colostrum found in the first few days is as a rule denser than is indicated by Woodward's average.

Transitional Period between Colostrum and Milk.—The character of colostrum milk, its changes and its disappearance, are shown by the observations of Adriance:[1]

CHARACTER AND VARIATIONS OF COLOSTRUM.

	MOTHER TWENTY YEARS OF AGE.		MOTHER NINETEEN YEARS OF AGE.		MOTHER TWENTY-THREE YEARS OF AGE.	
	Three Days.	Six Days.	Two Days.	Ten Days.	Six Days.	One Month, Seventeen Days.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Fat - -	4·52	2·80	3·77	2·64	4·30	4·08
Lactose - -	5·86	6·83	5·39	6·62	5·38	6·91
Proteids -	2·37	2·13	3·31	1·70	2·79	1·44
Salts - -	0·26	0·25	0·37	0·23	0·23	0·19
Total solids	13·01	12·01	12·74	11·19	12·70	12·62
Water - -	86·99	87·99	87·26	88·81	87·30	87·38

1 'Clinical Report on Two Hundred Cases of Human Breast Milk,' *Archives of Pediatrics*, vol. xiv., 1897.

The characteristic features of the colostrum are the low percentage of lactose, the excess of albuminoids and mineral salts, and, as a rule, the low percentage of fat, though, in regard to the amount of fat present, specimens vary greatly.

Townsend has shown that the shorter the colostrum period the smaller the so-called physiological loss of weight in the new-born (Rotch).

It is frequently stated that colostrum has a laxative effect on the infants, and hence assists in the expulsion of the meconium. This, in the light of the author's experience, must be considered very doubtful. He has not seen any advantages in the infant from the ingestion of colostrum, and many of the disturbances of digestion in the first week are caused by the excessive amount present in the mother's milk.

Physical Characters of Human Milk. — During full lactation human milk is bluish-white in colour, its odour is characteristic and the taste is distinctly sweet. Its reaction is invariably alkaline, and the specific gravity varies from 1028 to 1032.

Since the specific gravity is to some extent an index of the character of the milk, this point has received attention of numerous observers. Vanderpoel and John S. Adriance[1] name 1030 as the average figure. Holt[2] finds that the specific gravity is usually between 1029 and 1032. Monti[3] assessed the average maximum at 1034, and the average minimum at 1030. Richmond[4] allows the narrow margin of 1030 and 1031 as the average. The above observations are in remarkably close agreement, especially when it is borne in mind that some of the specimens included in the observations were abnormal, if not pathological.

[1] *Loc. cit.*
[2] 'Diseases of Infancy and Childhood,' 1903.
[3] 'Kinderheilkunde in Einzeldarstellungen,' Vienna, 1899.
[4] 'Dairy Chemistry,' 1899.

The specific gravity of human milk which may be regarded as typically normal is a remarkably constant figure. Specimens vary greatly in every respect, but those representing a normal milk, demonstrably capable of providing suitable and adequate food for the infant, though they still vary in composition, seldom exhibit any wide difference in relation to gravity.

According to the author's observations, 1030 may be regarded as the standard. Milks more than 1 below or above this figure usually present some abnormality, and frequently disagree with the infant. In comparatively exceptional cases milk may be of an altogether atypical character while nevertheless adequately meeting physiological requirements. Yet even these cases seem to be in the nature of adaptations to a different standard, rather than direct aberrations from the normal. In illustration of this point, which is of some clinical importance, the character of the milk of elderly primiparæ may be cited. In these women the milk is often found to be distinctly abnormal when compared with the typical standard; but the specimens present similarities of constitution in regard to their physical and chemical character, enabling them more or less definitely to be placed in a class typical of themselves.

Specific Gravity and Chemical Constitution.—When, however, we have to deal with specimens exhibiting pathological features, and which have failed to provide the infant's requirements, the variations may be extremely wide. As low a specific gravity as 1017 has been recorded by Adriance, and as high a figure as 1036 has been found by him and by Johannessen. It may be doubted whether these figures represent the extremes of abnormality; but the features of demonstrably pathological milks need not detain us, since they are of curious rather than clinical interest. The variations within normal limits of the specific gravity are of great importance in enabling us to

estimate quickly, though approximately, the character of the food supplied to the infant.

From the fact that fat is of low specific gravity, and rises to the surface as cream when milk is left standing for some time, a high percentage of fat tends to lower the specific gravity of the whole. Hence, *cæteris paribus*. an excessive specific gravity of a given specimen of milk means a deficiency of one of its most important elements. A milk of low specific gravity is often regarded as necessarily a poor one, whereas, in fact, the precise converse may be the case.

All the other solids, since their relative gravity is greater than that of water, increase the specific gravity in proportion to the amount present. Of these the only ones of importance in relation to gravity are the albuminoids.

The percentage of mineral salts present is too small to seriously affect the estimation, while the lactose is so remarkably constant that the variations due to this factor are so minute as to be almost negligible. These facts enable us to arrive at a generalization in regard to the probable constitution of a given specimen. Low specific gravity indicates excess of fat and deficiency of albuminoids; a mean specific gravity indicates a normal amount of fat and of albuminoids; a high specific gravity indicates an excess of albuminoids and a deficiency of fat. Though these facts may afford us some idea of the probable approximate constitution, the conclusions based on these would prove to be altogether fallacious in some cases—such, for instance, as in a milk containing a high percentage of both fat and albuminoids; for the excess of fat would counteract, in respect of gravity, the excess of albuminoids, and *vice versâ*. But with a knowledge of the specific gravity and of the percentage of either the fat or the albuminoids it is possible to arrive at the approximate constitution of a given specimen.

Holt's Method of Clinical Analysis.—Having regard to the clinical importance of a knowledge of the constitution of the milk in numerous cases of disturbed lactation, Holt[1] formulated a method by means of which the character of the milk may be approximately estimated. The specimen for examination should be taken from the 'middle milk,' and it should be removed by means of the breast-pump, great care being taken to prevent undue handling and to insure perfect cleanliness of the instruments. The specific gravity is then taken by means of a hydrometer, and the percentage of fat is determined either by means of the 'cream gauge' or by means of the Babcock machine. Where speed in the estimation is necessary, the machine is essential, as the cream gauge depends upon the separation of the cream by standing.

With the knowledge of the specific gravity and of the percentage of fat present in the specimen, certain general rules may be applied.

1. If the percentage of fat is high and the specific gravity is also high (for instance, 1033 or 1034), we may assume that the albuminoids are present in large amount; otherwise the excessive fat would bring the specific gravity below normal.

2. If the percentage of fat is low and the specific gravity is high, the albuminoids are probably normal in amount, since the high specific gravity is explained by the low fat percentage.

3. If the percentage of fat is high and the specific gravity is low, the albuminoids are probably normal in amount, the low specific gravity being accounted for by the high fat percentage.

4. If both the fat percentage and the specific gravity

[1] 'The Clinical Examination of Breast Milk,' *Archives of Pediatrics*, vol. x., 1893, *et vide op. cit.*

are low, the albuminoids are probably below normal, else the specific gravity would be raised.

In the following table these conclusions are summarized:

Percentage of Fat.	Specific Gravity.	Probable Amount of Albuminoids.
High -	High -	High percentage.
Low -	High -	Nearly normal.
High -	Low -	Normal.
Low -	Low -	Deficient.

These rules necessarily only provide us with a rough approximation, and the precise constitution of the milk should in all important cases be determined by a complete chemical analysis. For clinical purposes, however, it is often necessary to obtain some knowledge of the character of the milk as quickly as possible, and in this respect, when used with discretion and judgment, the method is a valuable one.

Human milk consists of water about 87 per cent., of lactose about 7 per cent., of fat about 4 per cent., of albuminoids about $1\frac{1}{2}$ per cent., and of nitrogenous extractives about 0·60 per cent., together with a small proportion of mineral salts amounting to about 0·20 per cent.

The product of the mammary gland varies greatly in different women, and in the same woman from week to week and from day to day, so that it is by no means easy to arrive at a composition which may be regarded as typical of normal human milk. Moreover, in attempting to arrive at the figures which may represent the average composition, we are at once met with the difficult question as to what may be regarded as the limits of normal variation.

This question is one of the most prominent factors in the confusion of statements by many observers. Thus, for instance, Monti, in assessing the average percentage

composition, includes in his calculations milks said to contain such high amounts that they must certainly be regarded as abnormal.[1] Another element of confusion is the tendency of writers to propound tables, either including or not including certain analyses of their own, but for the most part composed of the figures of other observers. By these means accurate observations cannot be improved, while the less accurate ones obscure those most exact. Hence, in endeavouring to arrive at the proper significance of any figures propounded, it is necessary for the student to be precisely acquainted with the actual factors of the assessment.

The inclusion of the observations of different observers is, of course, a perfectly legitimate proceeding and of distinct value, provided that the observers are all equally to be relied upon, and that the methods of analysis are either the same in all cases or may be regarded as equally accurate. On the other hand, the inclusion of inexact and discordant observations based on analytical methods proved to be inadequate can only give rise to unnecessary confusion and doubt.

Schlossmann's Analyses.—The results of 218 analyses of human milk were published in 1900 by Schlossmann.[2] The large number of analyses, and the fact that the Kjeldahl method, probably the most exact, was used throughout, make this series extremely valuable, and the results must be accepted as, necessarily, more reliable than the analyses of earlier workers which were based on less perfect methods. His figures are as follows:

---

[1] 'Monti's maximum of 5 per cent. proteids must be considered an abnormally high figure' (Judson and Gitting's 'Infant Feeding,' 1902).

[2] 'Zur Frage der natürlichen Säuglingsernährung,' *Archiv für Kinderheilkunde*, Bd. xxx. (1900).

TABLE SHOWING THE RESULTS OF ANALYSIS OF 218 SPECIMENS OF HUMAN MILK.

Number of Cases.	Days after Birth.	Fat.	Albuminoids.	Lactose.
6	9–10	4·23	1·81	6·92
25	11–20	4·63	1·81	6·89
41	21–30	4·53	1·94	6·77
21	31–40	5·00	1·50	6·97
13	41–50	5·41	1·75	6·80
24	51–60	4·62	1·56	7·28
10	61–70	4·69	1·44	6·94
19	71–100	5·39	1·25	6·77
25	101–140	5·10	1·25	6·94
15	141–200	4·02	1·29	6·89
19	Over 200	5·55	1·31	7·33

The average composition of human milk during the first seven months of lactation in regard to the amount of the lactose, fat, and albuminoids, is, according to these figures, as follows:

Lactose - - - -	6·95
Fat - - - - -	4·83
Albuminoids - - -	1·56

Schlossmann's account represents the results of extremely elaborate and detailed observations. Full particulars of the varying conditions, and of each case, are recounted in the original paper.

Differentiation of Proteids.—These analyses demonstrate that the proteid percentage is high in the first weeks of lactation, and that this gradually falls during the continuance of lactation. In this series no attempt was made to estimate the relative amount of caseinogen and of the whey proteids. In a previous analysis, however, Schlossmann found that, of the total albuminoids, 63 per cent. consisted of caseinogen, and 37 per cent. of lactalbumin. Lehmann and Bendix found the proportion to be 1·50 per

cent. of caseinogen to 0·5 per cent. of lactalbumin. Monti and Camerer have stated that the proportion of caseinogen increases as lactation becomes more advanced. Monti makes the extremely important observation that during the first months of lactation the especial characteristic of human milk is the high percentage of lactalbumin relatively to caseinogen. König estimated the relative amount present in human and cow's milk by the following figures:

	Human Milk.	Cow's Milk.
Caseinogen - - -	0·59	2·88
Whey proteids - - -	1·23	0·53
	1·82	3·41

Thus, the infant at the earliest period of life obtains the necessary proteid material in the most digestible form.

As in many other observations, the fat-content is shown to be especially liable to variation. Schlossmann's figures for the fat-content are, however, remarkably high, the *lowest* being over 4 per cent. This is certainly surprising, and the present author knows of no other extended observations showing such a high minimum percentage as this. If we compare, for instance, these figures with the cases cited by Rotch (p. 21), the contrast in this respect is very marked. The explanation probably lies in the diet of the women. The fat in human milk is the one element most susceptible to the precise character of the diet, and it is much more easy, as a rule, to increase or diminish this constituent than any other. For these reasons we may regard Schlossmann's figures for the average fat-content (4·83) as somewhat too high for use as a general standard.

In regard to individual cases, this observer found that, in those cases in which he was able to continue observations over a long period, the composition of the milk

closely corresponded with the average deduced. He found the amount secreted to be in excess of that usually accepted, and estimated the total amount secreted in the twenty-four hours to be from 1,000 c.c. to 1,600 c.c. (from 35 ounces to 56 ounces). As a rule, the infant received too much rather than too little.

This confirms the author's experience, and there seem to be definite clinical facts in explanation of the tendency of the healthy mother to overfeed her infant. Women secreting too small an amount necessarily and obviously fail to adequately meet the requirements of the infant, and in these instances supplementary substitute feeding becomes essential. In a number of these cases the milk-supply from the mammary gland of the mother becomes less and less adequate, and the supplementary feedings require to be proportionately increased. In other instances the mother encourages the suppression of lactation when she finds she cannot entirely feed the infant, and that the substitute food satisfies it. When these cases of insufficient supply are excluded, since the defect is obvious, the commonest defect is one of quality associated with excess of quantity. As a rule (which, however, is not without many exceptions), a normal quantity of milk secreted in a normal period of time is an indication that its chemical composition is approximately normal.

Carter and Richmond's Analyses.—Ninety-four specimens of human milk, taken from women in the lying-in department of the workhouse infirmary at Birmingham, were analyzed by Carter and Richmond.[1] Their results are summarized as follows:

---

[1] 'Observations on the Composition of Human Milk,' *British Medical Journal*, January 22, 1898.

TABLE SHOWING THE COMPOSITION OF MILK IN CASES IN WHICH THE HEALTH OF THE INFANT WAS NOT GOOD.

Water.	Fat.	Lactose.	Proteids.	Ash.	Infant's Condition.
86·75	3·23	—	-	0·38	Infant died.
86·95	2·94	5·78	4·05	0·28	
87·48	4·13	4·80	3·11	0·48	Infant died.
88·01	1·22	8·89	1·55	0·33	Infant failing.
88·09	3·28	5·60	1·76	0·27	Infant vomiting.
87·72	3·33	6·63	2·06	0·26	
87·71	3·37	6·72	1·95	0·25	
87·11	3·95	5·40	3·19	0·34	Vomiting, diarrhœa.
88·82	2·39	7·03	1·50	0·26	Infant failing.
89·40	2·66	6·03	1·64	0·27	
89·54	0·87	5·19	4·02	0·38	Died.
89·39	1·87	5·74	2·65	0·35	
90·13	0·99	5·35	3·16	0·37	
88·45	2·10	6·55	2·54	0·36	
88·36	3·70	5·53	2·05	0·36	
87·57	4·71	4·87	2·47	0·38	
87·35	3·43	6·42	2·48	0·32	Flatulence, diarrhœa, colic.
88·29	2·16	6·70	2·52	0·33	
89·29	1·59	6·86	1·97	0·29	Strophulus.
89·31	1·62	6·81	1·98	0·28	
84·72	6·65	6·64	1·77	0·22	
82·93	8·82	6·29	1·74	0·22	
89·53	0·81	6·50	2·83	0·33	Pain, diarrhœa, vomiting.
88·95	1·48	6·45	2·79	0·33	
90·59	0·98	6·52	1·71	0·20	Supply deficient; infants died.
87·65	4·07	6·31	1·77	0·20	

The average constitution of milk that disagreed with the infants was:

Lactose - - - -	6·28
Fat - - - - -	2·95
Proteids - - - -	2·36
Ash - - - - -	0·31
Water - - - -	88·10

After eliminating all milks disagreeing with the infants, the average composition was found to be:

Lactose - - - -	6·70
Fat - - - - -	3·11
Proteids - - - -	1·83
Ash - - - - -	0·24
Water - - - -	88·12

In the following table is shown the results of their analyses of milks agreeing with the infant, subdivided according to the date of lactation.

TABLE SHOWING THE COMPOSITION OF MILKS AGREEING WITH THE INFANT.

Time since Parturition.	Lactose.	Fat.	Proteids.	Ash.	Water.
4 to 6 days -	6·47	2·97	2·25	0·30	88·01
7 to 14 days -	6·62	3·06	1·85	0·26	88·21
15 to 29 days -	6·95	3·42	1·67	0·22	87·74
Over 30 days -	6·83	3·00	1·43	0·21	88·53

Söldner's Analyses.—A series of careful analyses were carried out by Söldner[1] after he had satisfied himself by control experiments that the Kjeldahl was the most reliable method. The breasts were completely emptied during the day, and during the night the infants were breast-fed.

TABLE SHOWING THE RESULTS OF SÖLDNER'S ANALYSES OF HUMAN MILK.

Days after Birth.	Albuminoids.	Unknown Extractives.	Albuminoids plus Extractives.
Colostrum, early - - - -	5·35	1·99	7·34
" late - - - -	2·90	1·33	4·23
Fifth and sixth days - - -	1·81	0·85	2·66
Eighth and ninth days - -	1·42	1·00	2·42
Ninth day - - - - -	1·40	0·80	2·20
Ninth and eleventh days - -	1·61	0·42	2·03
Eleventh day - - - -	1·61	0·94	2·55
Fourth, fifth, and eleventh days -	1·56	0·71	2·27
Twentieth and twenty-first days -	1·11	0·50	1·61
Twenty-ninth and thirtieth days -	1·04	0·35	1·39
Seventy-fourth day - - -	0·88	0·02	0·86
One hundred and thirteenth day -	0·88	0·06	0·94
Two hundred and twenty-ninth day - - - - - -	0·81	0·01	0·82

[1] *Vide* 'Analysen der Frauenmilch,' *Zeitschrift für Biologie*, 1896.

It is clear from these investigations and from those previously referred to that in the older analyses the percentage of albuminoids was considerably exaggerated. Especial value attaches to Söldner's results, in consequence of his important differentiation between the albuminoids and the extractives. Camerer and Söldner consider that the average composition of human milk during the second week of lactation is represented by the following figures:

	Per Cent.
Lactose - - - -	6·50
Fat - - - -	3·28
Albuminoids - - -	1·52
Citric acid - - -	0·05
Extractives - - -	0·78
Salts - - - -	0·27
Total solids -	12·40
Water - - - -	87·60

V. and J. S. Adriance's Analyses.—120 cases were analyzed by Vanderpoel and J. S. Adriance.[1] The women were healthy, and were of an average age of twenty-five years; sixty-five were primiparæ, and fifty-five were multiparæ. The breasts were not completely emptied, but the specimens were in every case removed after the infant had been suckled for two minutes. The method used was the same as in the preceding series. Their figures are as follows:

TABLE SHOWING THE RESULTS OF 120 ANALYSES.

Days after Birth.	Lactose.	Albuminoids.	Salts.
Second to fourteenth day	5·80–6·63	2·77–1·70	0·27–0·20
One month - - -	6·68	1·58	0·19
Three months - -	6·72	1·44	0·18
Six months - - -	6·78	1·25	0·16
Nine months - - -	6·84	1·04	0·16
Twelve months - -	6·90	0·83	0·15
Fifteen months - -	6·96	0·63	0·14

[1] *Loc. cit.*

These analyses again show the excess of proteids in the early weeks, and their gradual decrease in the later part of lactation. No mention is made of the nitrogenous extractives.

Mineral Salts.—The mineral matter present in human milk has been analyzed by various chemists, but, owing to the large amount of milk required and the difficulty of obtaining this, the definite results obtained in the case of cow's milk had not been obtained in the case of human milk. In 1893, at Rotch's instigation, a very complete investigation was carried out. In the course of a few weeks Rotch collected about 6 quarts of human milk. This milk was immediately reduced to its mineral constituents in Harrington's laboratory, and the figures below represent the results of the analyses of this mineral matter by Harrington and Kinnicutt:

The Mineral Matter of Human Milk.

Unconsumed carbon	0·71
Chlorine	20·11
Sulphur	2·19
Phosphoric acid	10·73
Silica	0·70
Carbonic acid	7·97
Iron oxide and alumina	0·40
Lime	15·69
Magnesia	1·92
Potassium	24·77
Sodium	9·19
Oxygen (calculated)	6·16
	100·54

Composition of the Mineral Matter Calculated from the above Analysis

Uncombined carbon	0·71
Calcium phosphate	25·35
Calcium silicate	1·35
Calcium sulphite	2·11
Calcium oxide	1·72
Magnesium oxide	1·91
Potassium carbonate	24·93
Potassium sulphite	8·04
Potassium chloride	12·80
Sodium chloride	23·13
Iron oxide and alumina	0·40
	102·45

The relative proportions of the salts in the form in which they occur in milk may therefore be approximately stated as follows:

Calcium phosphate	23·87
Calcium silicate	1·27
Calcium sulphate	2·25
Calcium carbonate	2·85
Magnesium carbonate	3·77
Potassium carbonate	23·47
Potassium sulphate	8·33
Potassium chloride	12·05
Sodium chloride	21·77
Iron oxide and alumina	0·37
	100·00

The most important differences between these and the older figures lie in the amounts of phosphoric acid, magnesium, silica, and alumina. The phosphoric acid and magnesium are less than half the amount previously recorded; the other two had not been discovered previously.

We are not yet in a position to make definite use of our knowledge of the character of the mineral matter, nor to state whether or not it has any practical bearings on nutrition, though it would appear probable that, within certain limits, a moderate excess is less to be feared than a marked deficiency. Elimination of any excess of salts is usually readily carried out by the kidneys and other organs, whereas it is to be presumed that radical deficiency would interfere with the due provision of the inorganic materials required for the structure of the tissues.

The above summary of the chemical constitution of human milk has been confined to the work of comparatively recent observers. König, Pfeiffer and many others, carried out investigations of the most valuable character at a time when analytical technique was far less advanced than it is at the present time, and to these pioneers the greatest honour is due. But there can be little question that the older analyses were less accurate

than the more recent ones, in consequence of the methods then available being less perfect. It would, therefore, only tend to confusion were these results blended with those of more recent date.

Bearing in mind the variations in human milk due to variations in the diet, in the external environment, and in the habits of women, together with differences resulting from the particular method of analysis, the observations of Schlossmann, Richmond, Söldner, and V. and J. Adriance, are in remarkable agreement in regard to the most important constituents of human milk.

Yet it must be admitted that the most perfect methods of chemical analysis at present known cannot tell us the precise composition of human milk. The importance of Söldner's demonstration of the nitrogenous extractives can scarcely be exaggerated. On the eighth and ninth days of lactation he assesses the amount of these at 1 per cent., an amount equal to more than two-thirds of the albuminoid content. Other observers have not taken account of this element in their analyses, and it is clear that, in regard to the proteids of milk, we are dealing with bodies of the precise composition of which we know very little.

Hence, it is important that in the study of normal and pathological lactation, and in the practice of substitute feeding, the standard of normal human milk should always be our first consideration. Our ignorance of some of the chemical factors renders it all the more necessary that clinical observations should also receive their share of attention. As our knowledge of the ultimate constitution of milk is limited, it is important, especially in reference to substitute feeding, that this should be remembered. The natural conditions should be adhered to as closely as possible, and the methods of modification should be devised so that, as far as possible, chemical or physical alterations of the primal proximate principles may be avoided.

These considerations are the more important since the results of analysis by the most competent chemists and the clinical results of equally competent physicians are in some points conflicting. No physicians, least of all those most prominently identified with the study of the nutrition of infants, would be prepared to base their methods upon a principle involving a high proteid percentage in the early weeks of life, and a gradually decreasing one as the infant developed; yet if we were to be guided solely by chemical analysis, the results recorded above leave us no choice. All are apparently agreed on this point. But the 'unknown extractives' of Söldner appear to indicate the nature of the difficulty.

The Nitrogenous Constituents.—There can be little doubt that the extractives are nitrogenous in character, and they must play an important part in the nutrition of the infant. In regard to chemical analysis also, the precise character of the albuminoids has not yet been determined by analysis, though the observations of Schlossmann, Lehmann, Bendix, Monti, Camerer, and others, all tend to show that the especial characteristic of the albuminoids of human milk rests in the high proportion of those forms represented by lactalbumin in contrast to caseinogen. Taking, therefore, the results of analytical and clinical observations in account, the following table may be regarded, in the author's opinion, as representing the nearest approximation to the constitution of human milk, at about the fourth week of lactation, which is as yet possible in reference to our knowledge of the various factors:

Fat - - - - -	4·00
Lactose - - - -	7·00
Whey proteids - - -	1·00
Caseinogen - - -	0·40
Nitrogenous extractives -	0·60
Mineral salts - - -	0·25
Water - - - -	86·75
	100·00

In regard to substitute feeding especially, the above figures represent the standard adopted by the author. The various factors will be dealt with in detail in reference to this subject. It need only be pointed out here that, if the above figures in any way indicate the constitution of human milk, the methods of modification which consist in merely diluting cow's milk with water are open to grave objections, not only in reference to the character of the proteids present in the mixture, but also in the depreciation of nitrogenous materials present in solution in the whey. Cow's milk apparently contains less of the nitrogenous extractives than human milk, and it is therefore important that their amount should not be further diminished. One-eleventh of the total nitrogen in human milk is present in the form of extractives, as compared with one-sixteenth in cow's milk. It is probable that the degree of energy and vigour of the infant is largely determined by the amount of these extractives present.

As Hutchison[1] points out, there is such a thing as degrees of health. 'Energy is not to be confused with muscular strength. A grass-fed cart-horse is strong; a corn-fed hunter is energetic. The brain appears to require nitrogen, and if proteid therefore be regarded as a nervous food, a diet rich in it will make for intellectual capacity and bodily energy.'

In the later months of the infant's life—that is, after the fourth month—the advantages of whey dilution are not so manifest, and in human milk at this period the amount of nitrogenous extractives appears to be very small.

Clinical Evidence.—Though in the present state of our knowledge the methods of chemical analysis are insufficient to fully inform us in regard to all the factors of infant nutrition, it is a striking fact that on the whole matter the most exact chemical and clinical observations

[1] 'Food and Dietetics,' p. 168.

are remarkably in agreement, and the study of the results of both methods of investigation throws more light on the subject than a study confined either to the one or to the other.

For it is as true of the infant as of the adult, that the element of the human individual demands the most complete recognition. No method of arbitrary rules, whether based on chemical or clinical observations, is likely to succeed.

Human milk is a food of varying composition, apart altogether from pathological changes. Rotch's figures showing the composition of the milk of different women, all of them successfully nursing their infants, afford an instructive example of this.

HUMAN BREAST MILK ANALYSES (HARRINGTON).

Mothers healthy, and infants all digesting well and gaining in weight.

	I.	II.	III.	IV.	V.	VI.	VII.
Fat - - -	5·16	4·88	4·84	4·37	4·11	3·82	3·80
Lactose - - -	5·68	6·20	6·10	6·30	5·90	5·70	6·15
Proteids - -	4·14	3·71	4·17	3·27	3·71	1·08	3·53
Mineral matter -	0·17	0·19	0·19	0·16	0·21	0·20	0·20
Total solids -	15·15	14·98	15·30	14·10	13·93	10·80	13·68
Water - - -	84·85	85·02	84·70	85·90	86·07	89·20	86·32
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
Fat - - -	3·76	3·30	3·16	2·96	2·36	2·09	2·02
Lactose - - -	6·95	7·30	7·20	5·78	7·10	6·70	6·55
Proteids - -	2·04	3·07	1·65	1·91	2·20	1·38	2·12
Mineral matter -	0·14	0·12	0·21	0·12	0·16	0·15	0·15
Total solids -	12·89	13·79	12·22	10·77	11·82	10·32	10·84
Water - - -	87·11	86·21	87·78	89·23	88·18	89·68	89·16
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

But though these milks are all to be regarded as physiologically normal, because they answer the most practical test, they can only be so accepted in relation to the mother and her infant. The interchange of infants immediately resulted in gastric and intestinal disturbance. Thus, by a process, the nature of which is unknown, between the secretion of the mammary gland of the mother and the digestive and nutritional needs of the infant a close correspondence exists. Whether, therefore, the infant be fed by the natural method or by substitution, the factors of nutrition involved are of serious moment, and not to be dealt with or calculated by any rigid formulas. The adjustment of the diet of the infant, when this is required, is one which demands clinical and physiological precision, with a due regard for all the essential factors.

CHAPTER II

LACTATION

In the virgin the mammary glands, when fully developed, form two conical, almost hemispherical, eminences situated towards the lateral aspect of the pectoral region.

Each breast corresponds more or less closely in length to the interval between the third and seventh ribs, and in breadth extends from the side of the sternum to, or somewhat beyond, the anterior margin of the axilla.

The dimensions and general development of the breasts vary at different periods of age and in different individuals. Before puberty they are small in size, but become much larger and more fully developed in correspondence with the development of the reproductive organs. The left breast is usually somewhat larger than the right.

At its base each breast is nearly circular, and its outer surface is convex. Situated just below its centre is a prominent erectile structure, the nipple (mammilla) the surface of which is usually somewhat darker in colour. The areola surrounds the nipple, and is generally of a tint intermediate between that of the nipple and the breast. In fair women the areolæ may be of a delicate rose tint; in others the colour corresponds in depth with that of the hair and complexion.

The nipple is provided with papillæ, and is perforated at its summit by the orifices of numerous lactiferous ducts. The areola is studded with rounded eminences

(Montgomery's glands), which become much enlarged during lactation. These glands secrete a sebaceous material, which lubricates the nipple so that it may be kept supple.

The breast structure consists of gland tissue supported by fibrous tissue. Interposed between the lobes is a considerable amount of adipose tissue. The gland tissue is pale red in colour, circular in shape, flattened from before backwards, and thicker at the centre than at the circumference.

It consists of numerous lobes, which are subdivided into extremely numerous lobules. The smallest lobules are composed of a cluster of vesicles opening into the branches of the proximal ducts. These ducts, uniting, form large tubules which terminate at the orifice of the nipple. The number of these main ducts is about fifteen to twenty, and they are termed the 'tubuli lactiferi.' They all converge towards the nipple from the various sections of the gland, and immediately beneath the areola are dilatations of the ducts, termed 'ampullæ,' which serve as reservoirs for the milk. At the base of the nipple the ducts again become contracted, and their orifices at the summit of the nipple are appreciably smaller in diameter than the ducts.

These tubuli lactiferi are lined with a single layer of columnar epithelium, except at their orifices, where the epithelium resembles that of the squamous type. In appearance the alveoli differ greatly, according to the precise condition of the gland. Each alveolus consists of a basement membrane lined with a single layer of cells, having a wide lumen when the alveolus is empty. Foster[1] describes the two typical phases of the gland as the loaded and the discharged.

The Discharged Phase.—In the discharged phase the alveolus is lined by a layer of flattened cubical cells, so that the relatively large area of the alveolus is almost wholly occupied by its lumen, in which some of the con-

[1] 'Text-Book of Physiology.'

stituents of milk may be retained. Each cell is composed of granular cell substance, in which is placed a rounded or oval nucleus. Sometimes the free edge of the cell is jagged and uneven, as if a portion of the free border had been torn away.

The Loaded Phase.—In a fully loaded phase the appearances are very different. The alveolus is lined with a layer of large cells, columnar in type, which project unevenly into the lumen, so that its area is much diminished and its outline is irregular. The cells contain two or more nuclei; the one near the base of the cell is well formed, while the others, near the lumen of the alveolus, show signs of degeneration. Occasionally constrictions are seen between the basal and peripheral portions of the cell, and detached cellular fragments are found in the lumen. In the cell substance, particularly in the peripheral portion, are numerous fat globules, and the larger ones project from the border of the cell. In addition to this extrusion of fat, the cellular substance itself breaks down and is thrown into the cavity of the alveolus. This cellular degeneration is apparently much more marked at the onset of lactation than when it is fully established, and probably accounts for the peculiar characters of colostrum.

Development of Breasts in Pregnancy.—From the onset of pregnancy, the breasts undergo a remarkable development. They become fuller and firmer, the nipples are much more prominent, and their erectility is greatly increased. The blood-supply is plentiful, and the full veins proceeding from the breasts form a network between the breasts and in the region of the upper part of the sternum. In a primipara, especially, these developments are so striking that they form a prominent feature in the diagnosis of early pregnancy. The chief development is in the glandular tissue; this becomes hard and nodular, and much more definitely palpable than in the virgin.

At about the tenth week of pregnancy a mucoid secretion forms in the gland, and, gradually oozing from the nipples, forms dried crusts, which adhere with some tenacity to the superficial epithelium.

Gradually the nipples and areolæ darken in colour; in fair women these changes may be slight, whereas in brunettes the depth of the pigmentation may be very marked. The areolæ become elevated above the surrounding skin, and Montgomery's glands become hypertrophied. At a later stage, about the fifth or sixth month, a secondary areola, in the shape of irregular pigmentation of the skin over the breasts, frequently occurs.

At the end of pregnancy the breasts are almost empty, save for a small amount of colostrum. In the course of three or four days they rapidly fill, and by the end of the first week lactation is fully established. In the first few days the fluid secreted is almost entirely colostrum. At the end of this period this secretion is replaced by milk; but for some time, not infrequently for as long as fourteen days, traces of colostrum may be found in the milk. In correspondence with the needs of the infant, the amount of milk secreted is at first small in amount, and gradually increases to meet the greater demand; while at a later period the activity of the gland begins to wane, so that the mother can no longer supply her infant with sufficient food.

Management of Lactation.—The proper management of lactation is of the greatest importance in regard to the health of the infant, and, in the great majority of cases where breast-feeding has to be prematurely given up after having previously proved to be quite satisfactory, this failure is the result of inadequate care. The mammary gland of the woman is exceedingly sensitive to both favourable and adverse conditions, and by the neglect of due precautions a milk fulfilling all the requirements may be speedily converted into a milk of a quite different character, with the result that the infant is at once in

danger. On the other hand, it is far too frequently assumed in such cases that the disorder in the infant demonstrates that the mother is unable to nurse her infant. In many cases, adequate regulation of the diet and exercise, and of the other factors involved in healthy lactation, results in the milk becoming normal in quality and suited to the infant's digestion.

Contra-indications to Lactation.—At the outset it must be determined whether it is advisable for the mother to attempt to suckle the infant. The reasons for forbidding this fall under two heads: those for the sake of the mother and those for the sake of the infant.

The presence of tuberculosis in any form, the presence of any symptoms or signs suggesting the possibility of tubercular affection, the fact that the mother comes of a stock disposed to tuberculosis, or possesses the facies and general appearance of one predisposed to this disease, should be considered absolute contra-indications to her undertaking the task of suckling her infant. Nothing assists the progress of the disease or renders its incidence in predisposed subjects more likely than lactation. Its effect in this respect is so great that, frequently, when nursing is undertaken and the disease is present, severe damage is done in a few weeks. The condition of the woman is altered altogether, and she becomes the subject of the infection in its acute form.

As to how far maternal nursing in these cases is a danger to the infant is as yet undecided; but the danger to the mother is so great that this question is of no practical importance.

The presence of chronic disease, such as chronic parenchymatous nephritis or any other disease entailing a serious weakening of the general organism, should again be an indication that maternal nursing is dangerous. The mother should not be allowed to suckle her infant if she has suffered greatly during pregnancy—as, for instance,

from chronic vomiting, or where exhausting complications have occurred immediately prior to, during, or after labour. Nor should nursing be permitted when any definite disease of the nervous system, either functional or organic, is present.

In cases of the above character, the duty of the medical adviser is clear, but in addition to these there is a large class of cases in which the advice to be given must depend on his judgment and upon the individual factors of each case. Nervous or neurotic women make bad nurses. The complications of lactation, in regard to emotional disturbance, will be more particularly discussed later; here it need only be said that extremely nervous women are only at all likely to be able to provide a suitable food if they are carefully and systematically tended, so as to protect them from everything in their possible environment likely to disturb them. It need hardly be said that in many instances this is extremely difficult, if not impossible.

Or, in other cases, the mother may be so frail and delicate of structure as to render any additional strain upon her organism inadvisable. Finally, it should be remembered that, while maternal nursing is the ideal method, it is a mistake to practically force a really unwilling mother to undertake the suckling of her infant. Many young mothers, not unnaturally anxious to avoid the severe restrictions and disabilities nursing imposes, are unwilling to accept the duty. But when the importance of breast-nursing by the mother is properly put before them, they cheerfully accept the duties and bear with the inconvenience. On the other hand, it is seldom wise to urge the duty upon a mother when there is little prospect that she will properly discharge it. It has frequently been necessary for the author to place an infant upon substitute feeding, not because the mother was unable to feed her infant, but because the life she led resulted in the infant

receiving a milk quite beyond its powers of digestion. Where it is possible to foresee such conditions, it is far safer that the infant should be substitute-fed from the beginning, rather than that all sorts of digestive disturbance should be created by its mother's milk, with the consequence that the re-establishment of the normal digestion is attended with delay and difficulty. In these cases the most that it is judicious to attempt is to induce the mother to nurse her infant during the first month of the puerperium.

Although the supply of milk may be plentiful, it may be of poor quality, so that the infant does not receive adequate nourishment; while in other cases the secretion of milk may be small or entirely absent, so that maternal nursing is impossible. Quite apart from the willingness of the mother, it is a fact that the capacity for maternal nursing among the more cultured classes of women is steadily decreasing. Cases are constantly coming under observation where the mother is extremely anxious to nurse her infant, and is fully prepared to make every sacrifice in order that she may be able to do this; but the milk provided by her is either so small in amount or so poor in quality as to render maternal nursing out of the question. It is a great mistake to encourage these mothers to persist in the attempt when the task is clearly beyond their powers, and great harm to the infant often results from an unreasoning adherence to maternal nursing. The increasing inability of women to nurse their infants, due undoubtedly to the effects of high civilization, is widespread and calls for adequate recognition. Holt of New York has drawn attention to his experience in that city.[1]

[1] 'In New York at least three children out of every four born into the homes of the well-to-do classes must be fed at some other font than the maternal breast. The percentage of successful maternal nursing is steadily diminishing every year, and even now an educated mother who successfully nurses her own infant for six months is a phenomenon, and one who can continue it for ten months almost a

Regimen of Lactation.—In those cases where breast-feeding is to be undertaken, due precautions must be observed, both prior to and during lactation, to ensure, as far as possible, the supply to the infant of milk of good quality and in sufficient amount. Everything must be done to maintain the mother in a perfect condition of health. She should have a plentiful supply of nutritious food in a form easy of digestion, and, in order to prevent intestinal disorder, it is usually wise, in the last month of pregnancy, to place the mother upon a more or less systematic dietary, in which unsuitable foods, condiments, etc., are directly forbidden.

Exercise in the shape of walking is important, and, unless contra-indicated, should always be insisted upon, as the absence of a proper amount of muscular exercise is prejudicial to the character of the milk. On the other hand, anything in the shape of excitement or fatigue should be especially avoided, and the woman should be encouraged to rest quietly after taking exercise.

Nervous Influences.—The nervous system should be stable and of good tone. Unrest, excitement, and worry are all extremely prejudicial to efficient lactation, and where they are well marked and the mother is impatient of control the prospects of successful maternal nursing are far from favourable. While it is generally advisable that moderate exercise be taken daily, there are some exceptions to this rule. In the last weeks of gestation some women show manifest signs of exhaustion. In such cases, unless the symptoms are treated, serious complications may arise. Exhaustion towards the end of pregnancy is an unsatisfactory feature, both with reference to lactation and to other factors of the puerperium, and calls for a thorough investigation. In all cases the patient should

curiosity. . . . It is not, as has been so often asserted, that the modern mother will not nurse; nearly all in my experience would be glad to do so if they could, but they simply cannot.'

remain entirely in bed until all signs of disorder have disappeared, and especial care should be taken of her during and after pregnancy.

Care of the Breasts.—The care of the breasts requires careful attention from about the third month of pregnancy. The mammillæ should be kept quite clean, and should be occasionally bathed with hot water, in order to effect the removal of the crusts which form on the surface as the result of the drying of the secretion which oozes from them.

If, in a young primipara, the breasts be unduly large from excess of adipose tissue, gentle massage of the breasts may be of great service by increasing the local circulation, and thus removing the superfluous fat. This point is not without its importance; women with breasts loaded with fat are seldom able to efficiently undertake maternal nursing. The comparatively small but firm breast is, as a rule, much more efficient, as in this form the glandular element is more active.

In addition to the careful cleansing of the nipples, attention is necessary to ensure their being sufficiently supple; if they are too dry, they should be gently and regularly anointed with lanoline in order to replace the deficiency of the sebaceous secretion. Anything tending to cause pressure of the nipples must be avoided, since this is likely to lead to retracted nipples. If the nipple is ill-developed or retracted, much can often be done by the patient herself to counteract this. She should be instructed to systematically draw out the nipple from the breast with her finger and thumb, lanoline being used as a lubricant to prevent chafing. Manipulations of this kind, when properly carried out, will frequently result in the formation of a nipple of proper size and sufficiently pliable, when previously the nipple was hard, small, and much retracted. The use of spirituous applications, such as eau de Cologne or methylated spirit, with the view of

hardening the nipples, is seldom to be recommended. In certain cases, where the tissue is too soft and without tone, these may be useful, but in a first pregnancy they are seldom indicated, and they tend to cause fissures and excoriations as a result of the ensuing brittleness. Where the secretion is abundant, as in some instances during the last month of gestation, suitable absorbent dressing should be applied to prevent chafing and irritation of the nipples and adjacent skin.

Pregnancy Corset-Belt.—Suitable support for the breasts is of the greatest assistance to the pregnant woman, and in the pregnancy corset-belt devised by the author due provision is made for this. At the back this corresponds closely to an ordinary corset, being shaped, boned, and laced in the usual manner. In the front, however, it is quite different from either the ordinary belt or corset. The breasts are supported by an elastic net, while the abdomen is supported by a shaped belt made of many pieces of elastic ribbon sewn together; this is laced at both sides to permit of the gradual increase in size. Light shoulder-straps are attached above, and suspender ribbons below. The whole thus gives a firm but elastic support, and allows of free movement without getting out of position.

The Diet of Lactation.—In regard to the diet suitable for lactation, there is considerable divergence of thought and practice; by some, great reliance appears to be placed upon the efficacy of certain foods and drinks in helping to produce a 'good milk.' As a matter of fact, the specific effect of diet is not marked in regard to lactation. Baumm and Illner made careful observations on the influence of the food taken by the mother on her milk. Various nursing women were fed on the following diets[1]:

1. An ordinary mixed diet taken in great abundance.

[1] Baumm and Illner, *Samml. Klin. Vorträge* (*Gynäk.*), xli., 1894, quoted by Hutchison ('Food and Dietetics,' London, 1900).

2. A highly nitrogenous diet—*i.e.*, one containing much cheese, eggs, and meat.

3. A diet rich in carbohydrates and fat, but poor in nitrogen—*i.e.*, plenty of bread, farinaceous foods, sugar, and butter.

4. A very fluid diet.

5. An ordinary diet plus 2 to 3 pints of lager-beer daily.

6. A diet consisting largely of salt fish, pickles, and other salt foods.

The milks were systematically analyzed, and they found that fat was the only ingredient of the milk on which the diet produced any appreciable effect. It was increased, sometimes rising 1 per cent., on the first and second diets only. Neither an abundant supply of carbohydrates nor even an increased amount of fat increased the amount of fat in the milk. In fact, the diets containing excessive amounts of fat seemed to lead to a lessening of the percentage of fat in the milk. It is also stated that neither the increase in the fluids taken nor the excess of salted foods led to any appreciable alteration in the milk. These experiments with the sixth diet must certainly have been conducted in women with vigorous digestions, otherwise severe alterations would have been experienced, arising from disordered digestion in the mother. It is, however, clear that the fat present in human milk is not necessarily derived from fat taken in the food of the mother. In the case of cows fed on grass, their milk yields a great deal more fat than can be found in their food. It may be further pointed out that the rigid diet so often insisted upon in the case of nursing mothers, to the exclusion of vegetables, fruits, etc., is not justified either by experimental investigation or by clinical results.

Alcohol in Lactation.—Alcohol in some form is frequently recommended to the nursing mother. Various observations have been made on the effect of alcohol on

the secretion of milk, with the general result that no definite or specific effect can be attributed to it. Some experiments by Klingemann,[1] in relation to the excretion of alcohol, are interesting. Two women each took 375 c.c. of sparkling wine containing 12 per cent. of alcohol; two other women each took 320 c.c. of port containing 18 per cent. of alcohol. On analyzing the milks no appreciable amount of alcohol was found in any of the cases. From these and other observations it is clear that alcohol is not excreted by the mammary gland unless the woman take such an amount as to produce a state of intoxication.

In regard to lactation itself, alcohol is of no value, and we are only justified in recommending it when its specific effect in the woman is to be desired. As an aid to appetite, and, in small quantity, a stimulus to digestion, it may be of great value. In such cases alcohol should be specifically prescribed in definite quantity at definite times. The routine administration of stout or other form of alcoholic liquor is certainly not to be recommended. In many cases it is decidedly injurious to the woman, especially when it interferes with, rather than aids, her digestion. It is also apt, when at all freely taken, to replace food, and thus interfere with the full supply of nutriment.

General Rules of Diet.—There is no special form of diet which can be recommended, and the best results will be obtained by adapting the diet to the individual requirements and idiosyncrasies of the nursing mother. So long as she is in bed after her confinement, or remains confined to her room, the diet should be light, and meat should be of small amount till she is able to take exercise. A plentiful supply of milk rich in cream is important, together with fish, chicken, eggs, bread-and-butter, etc., with such vegetables as can be taken by her without affecting the quality of the milk or disturbing the infant.

[1] Quoted by Cautley, 'Infant Feeding.'

In reference to potatoes and green vegetables, some care is necessary, as, unquestionably, in certain cases the infant is upset when the mother eats these; but it is a great mistake to arbitrarily forbid these, as in the majority of cases they can be taken in reasonable amount by the mother without producing any such effects. It is much better, therefore, to allow these to be taken at first in small quantity: and if any bad effect follows, the particular vegetable or other article of diet responsible must be altogether prohibited, or its consumption regulated according to the needs of the case.

Exercise.—Probably exercise is a more important factor than the precise diet. So soon as the mother is sufficiently convalescent, she should be encouraged to walk about her room and to systematically encourage muscular activity by various forms of exercise. In this respect calisthenic exercises and the use of very light dumb-bells are to be recommended. Later on, daily walking exercise to the point of moderate fatigue is of the greatest value in assisting the mother to provide her infant with a suitable milk. But here it must be admitted that the needs of the mother and of her infant are often directly opposed to each other. In the experience of the author, amongst gently-nurtured women, any form of fatiguing exercise is directly detrimental to the process of involution and its effective consolidation, and this factor must be borne in mind in determining the degree and nature of the exercise to be recommended. Where walking is considered inadvisable, general massage is of great value in replacing this to some extent.

Effects of Drugs.—The greatest caution is necessary in regard to the administration of drugs to the nursing mother. It is impossible to lay down definite rules as to what drugs may not be administered, if they are to be of universal application. In one case, for instance, the mother may be able to take the liquid extract of cascara sagrada.

without the slightest effect on the infant; in another the infant may suffer greatly. The saline cathartics almost invariably act on the infant when administered to the mother. In the author's experience, castor-oil is the only purgative that can be administered to the mother without fear of detriment to the infant; in rare instances even this drug appears to produce some temporary disturbance. It should be remembered that any drug is more likely to be transferred to the infant if lactation be disturbed than if it be normal. The list of drugs capable of affecting the infant through its mother's milk appears to be very extensive, so much so that it would perhaps be more convenient to name those that were not so transferable.

Of the clinical facts in connection with the administration of drugs to the mother, and their influence on the infant, the author has little or no experience, except with regard to purgatives. For if the mother is not well, and systematic medicinal treatment is indicated, then this is an indication for the suspension or termination of lactation.

Regulation of Breast-feeding. — In all cases the success or failure of breast-feeding must largely depend upon the way in which the practical details are carried out. Where the methods are haphazard, and the mother feeds her infant at all sorts of times, sometimes overfeeding and at other times underfeeding it, the results are always unsatisfactory, and the infant is constantly suffering from digestive disturbance in some form; while in other cases the effects are much more serious.

Twelve hours after birth the infant should be put to the breast and allowed to suck for two or three minutes. From this time to the time that the breasts are freely supplying milk, the infant should be given the breast every four hours. This stimulates the breast to secrete, enables the infant to obtain a certain amount of colostrum, and perhaps stimulates the contraction of the uterus, though,

in regard to this, the author must confess that his experience does not lend any support to this theory.

It is seldom advisable to allow the infant to remain practically unfed for three or four days because its mother is unable to provide it with food, and it is a serious mistake to allow the infant to take freely of the colostrum when this is plentiful. In anything but a small amount, colostrum seriously disturbs the infant—a fact that is not at all surprising when its chemical constitution is considered.

Preliminary Feedings.—At the end of the first twenty-four hours a normal infant of average development may, with advantage, be fed on a substitute food until its mother is able to nurse it. The composition of these preliminary feedings should be approximately as follows:

	Per Cent.
Fat	2·00
Lactose	5·50
Whey proteids	0·50
Caseinogen	0·15
Alkalinity	5·00

Ten feedings, each containing 1 ounce.

This early feeding prevents, partially or completely, the preliminary loss of weight, and more firmly and quickly establishes the vigour of the infant. In those cases where lactation is delayed or is inadequate, or where it is found advisable to suppress it, the advantage of this course is obvious. Where breast-feeding is undertaken in the ordinary course, the preliminary substitute feeding serves as an excellent introduction, so that symptoms of indigestion and flatulence, resulting from the first ingestions of breast milk, are much less frequent than when the infant is practically starved until lactation is established.

Nursing Intervals.—As soon as the process of lactation is fully developed, the infant should be fed every two hours in the day, and once at night. At about the sixth week the interval between the day feedings should be increased

to two and a half hours, and may then be allowed to remain the same until the infant is about twelve weeks old, when it need only be fed, in the day, every three hours. At about this period, also, the night feeding should be omitted. It is important that the infant should be so trained that the night feeding becomes unnecessary as soon as possible. A great deal in this respect can be done by an able and intelligent nurse; it is clearly to the advantage of the mother that she should not be disturbed in the night, and it is equally beneficial to the infant that its mother obtain the necessary rest.

The table below represents the intervals generally advisable, but it must always be understood that precise rules to apply to all infants cannot be formulated. A vigorous infant weighing $8\frac{1}{2}$ pounds at birth, and an infant born at full term weighing but 6 pounds, are very different individuals, and they require individual treatment; but whatever the intervals and the regulations of feeding be, they must be regular and systematic, if they are to be attended with success:

Age.	Intervals.	Total Number of Feedings.	Night Feedings.
First days - - - -	4 hours	6	1
First 6 weeks - - -	2 "	10	1
From 6 to 8 weeks - -	$2\frac{1}{2}$ "	8	1
From 2 to 4 months - -	$2\frac{1}{2}$ "	7	0
From 4 to 10 months -	3 "	6	0

Effects of Irregular Nursing.—When the mother nurses her infant at too short intervals, the proportion of total solids in her milk is increased, and when the intervals are unduly lengthened the increase in the amount of water renders the milk insufficiently nutritious, so that she is supplying her infant with a too dilute milk at too long intervals. As Rotch well says, irregularity in nursing, too frequent nursing, and too prolonged intervals,

so disturb the quality of human milk as to transform a perfectly good milk into one entirely unfitted for the infant's powers of digestion.

Complications of Breast-feeding.—The infant must not be allowed to feed rapidly: the breast-feeding on each occasion should extend over fifteen or twenty minutes. At the beginning of feeding the infant is hungry and eagerly gulps down an excessive amount unless restrained; this rapid feeding is a common cause of digestive disturbance. In order to prevent the incidence of parasitic stomatitis and other disorders due to the development of micro-organisms, the nipple and the mouth of the infant should be cleansed both before and after feeding, and for this purpose nothing is better than warm water. A dilute solution of boracic acid may be used if considered desirable; but it presents no advantages over plain water, and if a stronger solution is used it is likely to upset the digestion of the infant from some of the salt reaching the stomach. The solution of boracic acid acts as an astringent, and the frequent application to the nipples is likely to result in injury of the epithelium and consequent abrasion. In the case of the infant, parasitic stomatitis never develops unless milk remains stagnant in the mouth, thus providing a nidus for the development of the *Saccharomyces albicans*. If the infant regurgitates its food, the mouth must be cleansed on each occasion as the infection frequently arises from decomposition of the regurgitated food, rather than from traces of milk left in the mouth immediately after nursing.

Fissures and Excoriations.—Of the local complications of breast-feeding, the most frequent is sore nipples; and trivial as the affection may appear, few complications are so distressing to a mother anxious to nurse her infant. When a fissure is present, the pain caused by the sucking of the infant may be so severe that the mother is distracted by the conflict between her desire to nurse her

infant and her inability to bear the pain it causes her. For the cure of this condition a large number of preparations are recommended; but it is useless to attempt the treatment of the condition, if the infant is to be allowed to nullify all treatment by its vigorous sucking every few hours.

In all cases where the excoriation or the fissure is at all severe, the infant should be removed from the breast for twenty-four or forty-eight hours. This is the first essential to success. The nipple should then be bathed with hot water and dusted with boracic acid; continuous wet dressings are especially to be avoided. The milk should be drawn from the breasts by the breast-pump at the proper intervals, and the infant fed with this milk from a bottle. Orthoform is much more efficacious in annulling the pain than boracic acid, but it has the great disadvantage of being liable to cause extensive dermatitis. In one instance where this drug was used very freely, gangrene of both nipples ensued. An account of this case[1] was published by the author in the *Lancet*. When the nipple has sufficiently healed, the infant may be returned to the breast, with the interposition of a glass nipple-shield. In the worst cases it may be necessary to continuously use the breast-pump and to permanently inhibit direct suckling. This method is quite simple, and is much better practice than to allow the condition to recur again and again, with the result of great distress to the mother, and very probably of disturbance of the infant, from injury to the milk consequent upon the nervous exhaustion of the mother.

Other local conditions, such as mastitis, may interfere with suckling. Abscess of the breast is occasionally a complication, but the author has never seen a case except where maternal nursing was, and had been for some time,

[1] 'A Case of Gangrene of both Nipples occurring in the Puerperium,' *Lancet*, April 5, 1902.

absolutely contra-indicated. Where such a condition is threatening, the suppression of lactation for the sake of both mother and infant is absolutely indicated.

Lymphangitis Mammæ.—An interesting complication of the puerperium was first described by the author in 1902, under the name of 'lymphangitis mammæ.' The condition arises about the tenth day of the puerperium. About this time a pink flush may be seen on some part of the breast; this gradually develops, and in the course of twelve hours the following clinical picture presents itself: There is a wedge-shaped area of inflammation, the apex being at the nipple, the base being at some part of the junction of the breast with the chest wall. This wedge-shaped area is red, slightly œdematous, hot to the touch, tender, and indurated, the induration being distinctly outlined and definitely corresponding with the redness. The inflamed area is raised above the general breast surface, but the inflammation is confined to the superficial structures, and does not involve the mammary gland. During the development of this condition the temperature rapidly rises, the patient complains of pain in the breast and of headache, while constipation is frequently present. The treatment required is simple: The infant is taken from the breast, hot fomentations are applied to the inflamed part, and the patient is freely purged. Within about forty-eight hours the affection has disappeared. For an account of the cases and of the etiology of the condition, the reader is referred to the original description.[1] To those not familiar with the clinical characters of this typical condition, the local and general signs are somewhat alarming, as may be gathered from the above description.

Various difficulties arise in maternal nursing from ill-developed nipples, from weakness of the infant, so that it has not the necessary power to suck, or from congenital malformations, as in the worst cases of hare-lip and cleft

[1] 'Trans. Obst. Soc. of London,' vol. xliv.

palate. In these cases it may be necessary to use the breast-pump and feed the infant with its mother's milk from a bottle or spoon. In others a nipple-shield may be of use, or some other mechanical device suited to the character of the particular case may be required. The fact that the physical act of suckling is impossible or is inadequate should not be considered a reason for depriving the infant of its natural food. The complications of lactation due to the mother's inability to supply a milk of a character suited to the requirements of her infant require separate consideration. Two conditions which may occur during lactation need especial consideration in view of their effect on the mother, and consequently on her milk.

Catamenia during Lactation.—The onset of menstruation in a nursing woman may be attended with no signs indicating an alteration of the character of her milk; it may be attended with obvious signs for a day or two, which, however, quickly disappear, and are scarcely at all marked in the succeeding periods. In other cases the disturbance is acute, the character of the milk is radically altered, and from the onset of the catamenia the woman becomes completely incompetent as a nurse. It is therefore impossible to lay down any rule applicable to all cases. Menstruation sometimes appears about the third month after labour, and does not appear again for some months. Disturbance of the infant in these cases is, as a rule, either slight and evanescent or altogether absent. Where the catamenia are found to have become regularly established, it is the more necessary to determine the effect on the infant. In highly nervous women the alterations may be severe, and weaning of the infant forthwith is indicated; in others it may be advisable to feed the infant by substitution during the menstruation, and to return the infant to the breast when this has ceased. As a rule, when the woman has nursed her infant for six months, and trouble arises in consequence

of catamenial disturbance, it is advisable to wean the infant.

Pregnancy during Lactation.—In regard to the occurrence of pregnancy during lactation, the author cannot pretend to regard this as at all an open question. In few cases can the mother provide the infant with adequate food; in no case can she continue suckling when pregnant without endangering her own health and that of the fœtus. The worst cases of exhaustion in later pregnancy, in the author's experience, have always been cases where lactation has been maintained for a considerable period during pregnancy. There is no justification for this continuance, for, as a rule, the infant so nursed would thrive much better on an adequate substitute food, and the mother would be spared the strain of coincident lactation and pregnancy.

Defects of Breast Milk.—Human breast milk may be defective either in respect of quantity (excess or deficiency) or of chemical composition. In regard to composition, it may be said that the chief defects arise in the variations of the fat and the albuminoids. Lactose seldom varies to any great extent, and the slight variations do not appear to exert any directly prejudicial effect upon the infant. For the sake of convenience, the abnormalities of lactation may be somewhat arbitrarily classified as follows:

1. Cases where the secretion of milk is either practically absent, or is so small in amount as to be quite insufficient to meet the needs of the infant. In these cases substitute feeding is the only course available.

2. Cases where the secretion is abundant, but very poor in both fat and proteids. In certain cases this combination of large amount with a low percentage content seems to be in the nature of a physiological adjustment of the maternal and infantile organisms, and it must not, therefore, be hastily assumed that a milk of

poor quality is necessarily unsuited to the infant. Our attitude in regard to this must be determined by the condition and progress of the infant. In a great many of these cases, however, the results in the infant are far from satisfactory. As a rule, lactation of this character is generally found in weak, delicate women, and it may also be a prominent factor in the case that, even if the infant is progressing to some extent, the stress of lactation is obviously making great inroads on the strength of the mother, so that on her account nursing has to be terminated.

3. Cases where the amount is normal or approximately normal, but in which the constitution of the milk is abnormal. This may be in (*a*) excess of both fat and proteids, (*b*) excess of fat, (*c*) excess of proteids, (*d*) deficiency of both fat and proteids, (*e*) deficiency of fat, (*f*) deficiency of proteids.

Clinical Phases.—In reference to the clinical aspect of breast-feeding, three broad classes of abnormality are met with: those in which it is obvious, from the condition of the mother and the character of the milk, that she cannot supply her infant with the requisite food; those in which the milk is defective, but may with great care, possibly, though by no means certainly, be rendered adequate for the infant; and those in which the defect is so clearly due to some error of habit or diet that the due regulation and correction of these factors may be usually expected to prove completely successful.

In this matter nothing can replace clinical experience, but it is essential to success that the many factors of the subject be duly considered and estimated in their right proportion. It is illogical to deduce, from the general principle that human milk is the standard food for the infant, that the milk of an individual mother is the ideal food for her infant. Among the women of the wealthy classes it is comparatively rare to find a mother able

to nurse her infant, however willing, and, indeed, in some cases anxious, she may be to do so. The whole life of these women is, as a rule, antagonistic to the normal functions of the mammary gland. When, therefore, there is no reasonable probability of maternal feeding being a success, it is highly prejudicial to the infant to attempt this.

Further, in those cases where there are gross defects in the milk, it must be remembered that the co-operation of the mother in regard to her diet, her environment, exercise, regularity of nursing—and many other factors, varying in each case—is of the first importance. Where there is some prospect of this co-operation being really forthcoming, then there is justification for the attempt to convert the bad food into a good one. Where there is little or no probability of this assistance on the part of the mother, it is unreasonable to make use of methods primarily based on such assistance.

On the other hand, given a willing and intelligent mother, anxious to nurse her infant, prepared to observe the necessary rules and restrictions, and where the defect is one of relative constitution as opposed to absolute inadequacy of the milk supplied by her, then the attempt to improve the composition of the milk is one likely to succeed, and to be attended with the best results to the infant.

The principles which must guide us in altering the character of the milk so as to suit the infant's requirements need to be considered in some detail. The lactose and the salts are fairly constant factors in poor and rich milks alike, the proportionate amounts present are approximately the same; what variations are to be found cannot, in the present state of our knowledge, be definitely attributed to any one factor in diet or habit.

The Varying Elements of Milk.—The constituent elements—fat and proteid—vary to a very great extent,

and are largely influenced by the condition of life of the nursing woman. Hence, by regulating these conditions it is possible to modify the proportions of these bodies present. Certain clinical facts here are of importance, but, as they are generalizations from many observations, they must not be accepted as necessarily applicable without qualification to any individual case.

The fat in human milk is present in some sort of proportion to the amount of nitrogenous material and fat present in the diet of the woman. The fat apparently acts as a proteid-sparer, while the proteid probably acts more directly in relation to the metabolism of the mammary gland. Whatever may be the reason, a proteid food, such as meat, is much more likely to increase the fat in the milk than a diet containing fat and little proteid. In regard to the proteid constituents, they are rarely deficient in amount unless the milk is a very dilute one, due either to irregular nursing or to inadequacy of the mammary gland. Excess is the general defect found in respect of proteid, and to correct this excess nothing is so important as systematic daily exercise in the shape of walking, combined with careful attention to the general health and regulation of the diet.

A general poorness in the total solids of the milk may be due to the fact that the intervals of nursing are too prolonged; this always tends to increase the percentage of water at the expense of the other constituents. Hence, when the analysis shows the milk to be of such a character, the nursing of the infant should be at shorter intervals. The diet should be carefully attended to, so that the mother receives a full supply of nutritious material in an easily assimilable form, and, in order to secure the restoration of the disturbed metabolic equilibrium, rest in bed should be ordered. It may be well to restrict the liquid portion of the diet within reasonable limits, but it is doubtful whether a moderate

amount of liquid plays any part in the amount of water present in the milk, provided the diet in other respects contains the necessary proximate principles. The balance of water in the tissues is adjusted by renal action. As has already been pointed out, in those cases of poverty of the milk the condition of the mother must always receive adequate consideration ; if she is suffering in health or losing weight, it becomes necessary to terminate the lactation and to resort to substitute feeding.

Emotional Disturbance.—It must also be remembered that disturbances of lactation are by no means always due to errors of diet, or too much or too little exercise. Perhaps the most frequent instances of seriously disturbed lactation are to be found in highly nervous women. Emotional disturbances in this type of woman produce profound alterations in the composition of milk, while other factors, such as illness, the occurrence of the catamenia, or of pregnancy, are frequently responsible for alterations in the milk.

As so much depends on the nursing mother, the attempt to regulate the character of her milk is one requiring in some cases a great deal of patience. Failures occur which are sometimes extremely disappointing to the physician. Yet in many cases the results are extremely satisfactory. The following cases have been selected to illustrate some of the main features of management and treatment :

Illustrative Cases.

CASE I. : *Disordered Lactation due to Errors of Diet and Habits.* —M. M., aged thirteen weeks. The infant had been well during the whole of the first month. During the second month at intervals it had suffered a good deal from flatulent indigestion, attended with greenish motions. When the infant was seen, it had been suffering severely from gastric and intestinal disturbance, and was evidently in great pain. Sour vomiting of small amounts occurred persistently.

The motions were very offensive, grass green in colour, and contained large curds.

The history of the lactation pointed at once to the prime cause. Up to the end of the second month the mother had taken care of herself, at first being at home during the lying-in, and then in the country. On her return to town she gradually took up her usual life, lunching and dining out, frequently going to the theatre, etc. It was easy to see that during the latter half of each day the feeding of the infant was very irregular, being dependent on the mother's ability to fit in the nursing with her other engagements. It was also assumed without any doubt that the nature of many of her meals was highly improper for a nursing woman, and her exercise was practically non-existent, as she invariably made use of her carriage. This mother was extremely anxious to nurse her infant, but she had not been at all adequately informed of the care she must take of herself, and was clearly quite unaware that she was responsible for her infant's sufferings.

The digestive disorder was treated, and the infant was placed for the time being on substitute feeding. A specimen of the mother's milk was taken for analysis. The breasts were emptied by the breast-pump every three hours, and the mother gave up all her social engagements, and was placed upon a simple diet. In accordance with instructions, she also took walking exercise daily, one and a half miles in the morning and the same distance in the afternoon. At the end of a week the milk had much improved, and at the end of ten days was in a condition apparently fit for the infant. The substitute feeding was then given up, and the infant was returned to the breast: the nursing was carried out with great care and at regular intervals, and the infant did well. The figures show the condition of the milk (I.) at the time of the illness, and (II). after ten days' regulation of the diet, etc., as described above:

	I. Per Cent.	II. Per Cent.
Fat	1·25	3·57
Lactose	7·00	6·35
Proteids	3·95	1·87

The above case illustrates the satisfactory results that can be obtained with the co-operation of a mother willing to carry out the instructions to the best of her ability. The next case presents other features.

CASE II.—The infant was under the care of the author from its birth. During the first three months its progress was very satisfactory, save for some temporary disturbances caused by the infant

taking the milk too rapidly from the breast. When this was corrected the progress was uninterrupted.

For the period of three months the mother was resting. At the end of this she returned to town. Being of an intellectual and highly excitable temperament, she took a great and active interest in many affairs. She then altogether overtaxed herself, and six weeks after returning to town took to her bed in a state of nervous prostration, which had been suddenly intensified by the death of a relative. This alternation of apparent health and nervous collapse had already occurred on more than one occasion prior to the birth of the infant. The effect of her condition on lactation was extremely prejudicial.

The details of the case need not be stated in full, but the facts concerned with the character of her milk are interesting, as they clearly illustrate the alterations caused by emotional disturbance. The figures below show the composition of the mother's milk at a time when she was well. The analyses were made as a matter of precaution. I. represents the composition of the milk at the ninth day of the puerperium ; II. the composition at the end of the third month :

	I. Per Cent.	II. Per Cent.
Fat	3·12	3·87
Lactose	6·21	6·49
Proteids	1·34	1·28

On the first occasion of disturbance the infant was in great pain, and the symptoms of intestinal indigestion were severe, the gastric symptoms not being very marked. The mother was in a highly excited condition, lamenting that she was injuring her infant and complaining of many disappointments as a result of her collapse. The analysis of her milk showed the following constitution, which was in marked contrast to those above recorded :

	Per Cent.
Fat	2·21
Lactose	6·31
Proteids	3·56

Substitute feeding was undertaken ; the mother was given alcohol to induce sleep ; her general condition was attended to, and the breasts were regularly exhausted at the usual intervals. At the end of a fortnight she had completely recovered, and her milk on analysis showed the following composition :

	Per Cent.
Fat	3·45
Lactose	6·40
Proteids	1·35

The infant was then returned to the breast, and did well. Three

weeks later the mother again broke down suddenly, and with symptoms similar to those already described. On analysis her milk proved to be composed of—

	Per Cent.
Fat - - -	1·25
Lactose - -	5·00
Protéids - -	4·10

The condition of the infant was extremely critical for some days : at first from convulsions, which did not yield readily to treatment, and from severe gastric and intestinal disorder ; and finally from exhaustion and collapse. After four days, in which its condition gave rise to great anxiety, the infant showed signs of recovery, and then gradually became quite restored to health. The composition of its substitute food was :

	Per Cent.
Fat - - -	3·50
Lactose - -	6·00
Proteids - -	1·25
Alkalinity - -	5·00

Heat at 150° F. ; seven feeds, each containing 5 ounces.

Maternal nursing was now considered to be far too dangerous to the infant, and lactation was suppressed.

This case is instructive in showing the existence of neurosis as a contra-indication to maternal nursing. An attempt was made to maintain maternal nursing when it ought to have been abandoned, on the occasion of the first failure. Being acquainted with the nervous temperament of the mother and all the facts of the case, it would have been much better if the author had adequately realized the meaning of these facts and forthwith weaned the infant. His failure to do so resulted in the life of the infant being seriously imperilled five weeks later. Yet cases of this kind are quite commonly treated as if the condition of the infant were due to faults of its digestion rather than of its food. In consequence, the infant is dosed with grey powder, castor-oil, and all sorts of expedients are resorted to, while the prime source of the disorder remains untouched.

These cases of disordered lactation arising from emotional disturbance in neurotic women are, in the

author's experience, extremely unfavourable; they react to the regulation of habit and diet much less satisfactorily than do those cases where excess of rich food and absence of exercise is the cause of the disorder. Hence, there should be no undue delay in determining the course to be taken. If serious disturbance arises from nervous causes under circumstances which indicate that it is likely to recur, substitute feeding is by far the safest course to adopt. One important qualification, however, must here be made. In some cases, excessive emotional excitement may be manifested by a mother without affecting her milk to any serious extent. These women are of a different type. They are vigorous and passionate, but not neurotic. An analysis of the milk is the important point in determining the nature of the case. When a sudden and prejudicial alteration occurs in conjunction with nervous symptoms, there should be no hesitation in terminating lactation.

The next case affords an illustration of one of the unavoidable dangers of maternal nursing:

CASE III.—An infant, four months old. Maternal nursing had been carried out with satisfactory results, and the infant had regularly gained in weight. At this time the mother was severely poisoned, in all probability by some food. She definitely attributed it to a certain meal, but no satisfactory evidence on this point could be obtained.

About an hour and a half after this, though feeling indisposed, she suckled her infant. Soon after this she was attacked with violent diarrhœa. The mother was in a critical condition for some days, and the illness was complicated by the development of colitis. Fortunately for the infant, the mother was too ill, at the time the next feed was due, to think of nursing it. Within a few hours of the single feed (after the mother's poisoning) the infant developed the most acute symptoms of gastro-enteritis. Vomiting and diarrhœa set in, and threatened to be almost continuous. In the space of twenty-four hours the infant seemed to be almost moribund. The stomach and the colon were irrigated, brandy was freely supplied, and the infant was kept warm by hot-water bottles packed around it. It was given a solution of 10 per cent. lactose—3 ounces every hour—which it took greedily. Two teaspoonfuls of castor-oil were given after vomiting had ceased

for three hours, and this was retained. After complete deprivation of food for twelve hours, it was given a substitute food as follows:

	Per Cent.
Fat - - -	1·00
Lactose - -	5·00
Whey proteids - -	0·50
Caseinogen - -	0·10
Lime-water - -	10·00

Unheated; twenty feeds, each of 1 ounce.

(The term 'unheated' is, of course, a laboratory instruction. Each feed was raised to 100° F. immediately before being given to the infant.)

The feeds were ordered to be given every hour. Though the infant was very weak, and had lost 2 pounds in weight, it soon began to show signs of improvement, and on the fifth day it was making very distinct progress.

The illness of the mother precluded any attempt at the renewal of maternal nursing. The infant did well on the substitute food, which was gradually enriched. At the end of three weeks from the attack it was digesting well a food according to the following prescription:

℞	Per Cent.
Lactose - -	6·50
Fat - - -	3·75
Proteids - -	1·50
Alkalinity - -	5·00

Unheated; seven feeds, each of 5¼ ounces.

As is well known, the mammary gland during lactation actively excretes many forms of poisonous products. This, which accounted for the perilous condition of the infant, was taken advantage of, and in order to secure, as far as possible, the rapid elimination of the poison from the mother, the breasts were regularly pumped. In a few days, however, the secretion of milk quite ceased.

Mixed Feeding.—In certain cases, where the mother is unable to sufficiently supply her infant, the method of mixed feeding is frequently resorted to. It not uncommonly happens that at the beginning of lactation the mother is unable to provide all the food required by the infant. In these cases the occasional feeding of the infant by substitution is of the greatest value, since it

provides the infant with what it requires and gives the mother time for the full development of lactation. But in those cases in which, when lactation has previously been sufficient and has adequately met the requirements of the infant, the milk-supply begins to fail, the advisability of mixed feeding is, in the author's opinion, much open to question.

The failure of the mammary gland must be regarded as an indication of exhaustion. In the interests of the mother it is unfair to advise her to continue nursing when evidence of the stress is present; in the interests of the infant it is unwise to continue to rely upon the mother when her ability to nurse is demonstrably failing. With the qualification above referred to, the author has seldom found mixed feeding to be of advantage to either mother or infant. It is undoubtedly the case that the deficiencies of the mother can to some extent be met by the substitute food; but it is far from clear that it is to the advantage of the mother that lactation should be allowed to continue when it is demonstrated that the provision of the food meeting her infant's requirements is beyond her powers. In these cases the health and strength of the mother is an important factor which needs the fullest consideration. Failing lactation is, as a rule, an indication that the task is too much for the woman; and it must be remembered that this function is no light one. Hutchison,[1] assuming that the whole potential energy of milk could be converted into work, has calculated that the chemical energy which a mother expends daily in nursing an infant six months of age would be sufficient to raise a ton weight about 800 feet.

Weaning.—When weaning of the infant has to be undertaken either at the normal period or earlier, it is important that this should be carried out without distress to either mother or infant. In all cases where it

[1] *Op. cit.*, p. 427.

is practicable, the weaning should be made a gradual process. The rules guiding us in this matter vary according to the nature of the case. Where the infant has been fed by its mother for the normal period, and the termination of lactation becomes necessary for physiological reasons, the condition of the infant should be carefully inquired into. If it has gained weight regularly, and its development has been continuously satisfactory, the maternal milk should be our guide as to the composition of the food of the infant. Before undertaking the substitute feeding, the mother's milk should be analyzed. The milk mixture should then be graduated in accordance with the results of this analysis. It is well, however, at first to slightly diminish the albuminoid percentage. This is by far the commonest cause of digestive disturbance, and until the infant is satisfactorily established on its new food it is better to keep the amount of albuminoids somewhat below normal. As soon as it is clear that the infant can digest the food without difficulty, this can be gradually raised. When the age of the infant indicates this, the milk mixture should be gradually approximated to the composition of whole cow's milk, so that in due course this may be legitimately provided.

In other cases, for a variety of reasons, it becomes necessary to wean the infant long before the normal term of lactation. As a precautionary measure, it is always advisable to obtain and analyze a specimen of the mother's milk when the infant is thriving, and when, probably, there is no question of weaning. Should the suppression of lactation become necessary at a later period, the knowledge derived from this examination is of great assistance in indicating the precise quality of the substitute food to be prescribed. In all cases where the termination of maternal nursing is not urgently called for, the lactation should not be suppressed till it has been ascertained clinically that the substitute food is suited to the digestion

of the infant and meets all the requirements of nutrition. This delay provides the opportunity for further modifications and adjustments until the necessities of the case are duly appreciated and provided for. It is a serious error to adopt procedures rendering the mother unable to nurse her infant before the precise quality of the substitute food has been accurately determined by clinical evidence.

In reference to those cases where the function of the mammary glands is not performed at the outset, or fails suddenly, or where for other reasons substitute feeding becomes necessary, it need only be said that the factors of general nutrition should be, for the moment, entirely subordinated to the immediate object of establishing the infant on a graduated milk without resulting digestive disturbance. As soon as this has been accomplished, the enrichment of the diet so as to provide a food meeting the full requirements can be gradually carried out.

CHAPTER III

COW'S MILK

When for any reason maternal nursing is inadvisable or impossible, the infant has to be fed on milk derived from another woman or from some animal. Of animal milks, there is only one, that from the cow, which can be readily obtained in sufficiently large quantities at a moderate cost. This milk, as the basis of the substitute food, therefore needs detailed consideration.

Physical Characters.—Cow's milk is an aqueous solution of lactose, albumin, and salts, holding in suspension globules of fat and containing caseinogen, combined with certain of the salts in a state of semi-solution.

Its reaction when freshly drawn is amphoteric; but cow's milk soon becomes acid on standing, and the degree of acidity is greatly increased when the milk is allowed to remain in a moderate temperature for the space of twenty-four hours.

The specific gravity of the mixed milk of a herd is usually between the limits of 1030 and 1034, the average specific gravity being 1032. This factor varies according to the amount of the total solids, the nature of the variations being of the same character as those described in reference to human milk.

Average Composition.—Richmond,[1] on the basis of about 200,000 analyses, formulated the average chemical composition of the milk as follows:

[1] 'Dairy Chemistry,' p. 120. London, 1899.

	Per Cent.
Fat	3·90
Lactose	4·75
Caseinogen	3·00
Albumin	0·40
Ash	0·75
Water	87·10

These figures may, from the large number of analyses, be regarded as representative of the typical composition of cow's milk when the cows are fed by the ordinary methods, and where numbers of cows are included, so that the amount of total solids is low. Where the cows are selected and their diet and environment are carefully designed to produce a milk of fine quality, the fat and proteids stand at a higher figure. Rotch has investigated the character of the milks of various cows with special reference to their fitness for infant feeding, and he selected the following breeds as being most suitable.

Differences of Composition in Various Breeds.—The **Shorthorn** has constitutional vigour, a sound digestion, with great capacity for food, is of a placid temperament, and her milk is rich in total solids. The average composition of her milk is:

	Per Cent.
Fat	4·04
Lactose	4·34
Albuminoids	4·17
Mineral matter	0·73
Water	86·72

The **Devon** is of a similar character, the total amount of milk provided being, as a rule, rather less. Her milk is of the following approximate constitution:

	Per Cent.
Fat	4·09
Lactose	4·32
Albuminoids	4·04
Mineral matter	0·76
Water	86·79

The **Ayrshire** breed is strong and vigorous, but these cows are more susceptible to their surroundings by reason

of their temperament being more nervous. Their milk is represented by the analysis below :

	Per Cent.
Fat - - -	3·89
Lactose - -	4·41
Albuminoids - -	4·01
Mineral matter -	0·73
Water - - -	86·96

The **Holstein-Friesian** represents the type of cow most suitable for laboratory purposes. The ordinary dairyman, however, does not as a rule regard her with favour, since, though her yield of milk is exceptionally large, the total solids are low in amount. Moreover, where whole milk is also required she is distinctly unsuitable. The amount of fat is less than the minimum for milk on sale permitted by Government regulations (3 per cent.). The constitution of this milk is :

	Per Cent.
Fat - - -	2·88
Lactose - - -	4·33
Albuminoids - -	3·99
Mineral matter -	0·74
Water - - -	88·06

Several other varieties may be used, but the above specimens indicate the general characteristics of the cows suitable for the puposes of infant feeding.

Variations in Cow's Milk.—In relation to this aspect of the subject, it must be remembered that cow's milk, like human milk, is liable to variations from day to day, these variations being dependent on changes of diet, environment, etc. Further, various other factors are known to be definitely associated with changes in the quality and character of the milk.

In the following table, quoted from Richmond,[1] are shown the variations in the total solids, fat, and solids-not-fat, as determined by Vieth from analyses of the milk

[1] 'Dairy Chemistry.' London, 1899.

of the cows kept at the Horsham Farm of the Aylesbury Dairy Company:

TABLE SHOWING SOLIDS IN MILK OF COWS OF DIFFERENT BREEDS (VIETH).

Breed.	Total Solids.			Fat.			Solids-not-Fat.		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Dairy Shorthorn	18·7	10·2	12·90	10·2	1·3	4·03	10·6	7·6	8·87
Pedigree Short-horn - -	16·8	10·5	12·86	7·5	1·9	4·03	9·8	7·6	8·83
Jersey - -	19·9	11·0	14·89	9·8	2·0	5·66	10·4	8·1	9·23
Kerry - -	18·6	10·6	13·70	10·5	1·8	4·72	10·6	4·9	8·98
Red-polled -	16·2	9·7	13·22	6·6	2·5	4·34	10·2	7·1	8·88
Sussex - -	17·4	11·5	14·18	7·6	2·9	4·87	10·3	8·4	9·31
Montgomery -	16·1	10·2	12·61	6·5	1·4	3·59	10·0	7·9	9·02
Welsh - -	17·6	11·9	14·15	8·3	3·0	4·91	9·6	8·9	9·24

Nervous Influences.—The cow is a nervous animal, peculiarly susceptible to environment. Emotional disturbance in the human mother is probably the most frequent cause of pathological changes in her milk, and this fact has already been illustrated. It is interesting to note that observations of a very different character seem to show that disturbances of a like nature occurring in the cow produce similar results. When cows are exhibited at agricultural shows, the proportion of the total solids of their milk is almost invariably seriously altered. Richmond states that the low fats recorded in a certain series were due mostly, if not entirely, to this cause. Dyer has recorded the case of a cow which, during exhibition, secreted a milk containing but 1·85 per cent. of fat. On the day after the exhibition her milk contained 3·64 per cent. of fat. The environment of milch cows is therefore an important matter, and requires special recognition in reference to infant feeding. Variations within moderate limits occur in the same cow from day to day, so that for all purposes

it is much better that the milk should be derived from a number of cows rather than from one.

Seasonal Variations.—Definite alterations in the character of cow's milk occur according to the season. During November, December, and January the milk is rich in fat and in the other solid constituents. In the months of February, March, and April the milk is less rich in fat, but the other solids are not appreciably diminished. From May to August the fat is smaller in amount, and in July and August the other solids are less in amount than usual. During September and October the milk gradually increases in richness to the standard of the winter months.

Richmond has published a table graphically illustrating these seasonal changes:

SEASONAL VARIATIONS IN COW'S MILK.

Month.	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.
		Per Cent.	Per Cent.	Per Cent.
January	1·0322	12·88	4·02	8·86
February	1·0322	12·78	3·93	8·85
March	1·0322	12·71	3·88	8·83
April	1·0322	12·66	3·84	8·82
May	1·0323	12·66	3·82	8·84
June	1·0322	12·59	3·79	8·80
July	1·0317	12·66	3·93	8·73
August	1·0316	12·73	4·02	8·71
September	1·0319	12·92	4·12	8·80
October	1·0322	13·13	4·21	8·92
November	1·0322	13·19	4·30	8·89
December	1·0322	13·04	4·16	8·88

Daily Variation.—It is well known by all practical dairymen that the evening milk is richer than that of the morning, and for this reason, in connection with laboratory feeding, the morning milk is used for the purpose of preparing modified milk mixtures, while the evening milk is reserved to supply the demands for whole milk. The evening milk is richer in all the solids. This is well illustrated in the table appended:

COMPOSITION OF MORNING AND EVENING MILK.

Month.	Morning Milk.				Evening Milk.			
	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.	Specific Gravity.	Total Solids.	Fat.	Solids-not-Fat.
January -	1·0327	12·76	3·71	9·05	1·0324	13·16	4·10	9·06
February -	1·0327	12·63	3·61	9·02	1·0324	13·02	4·00	9·02
March -	1·0327	12·63	3·61	9·02	1·0323	12·96	3·95	9·01
April -	1·0327	12·58	3·56	9·02	1·0325	12·93	3·90	9·03
May - -	1·0328	12·42	3·40	9·02	1·0323	12·76	3·79	8·97
June - -	1·0323	12·31	3·42	8·89	1·0318	12·55	3·72	8·83
July - -	1·0316	12·24	3·50	8·74	1·0312	12·50	3·80	8·70
August -	1·0315	12·40	3·65	8·75	1·0313	12·69	3·96	8·73
September	1·0321	12·61	3·71	8·90	1·0318	13·07	4·15	8·92
October -	1·0328	12·83	3·75	9·08	1·0324	13·23	4·17	9·06
November	1·0329	12·89	3·78	9·11	1·0325	13·27	4·17	9·10
December	1·0327	12·87	3·80	9·07	1·0324	13·24	4·17	9·07
Average -	1·0325	12·60	3·63	8·97	1·0321	12·95	3·99	8·96

This variation is not so much due to the precise time of milking as to the fact that the interval between the morning and evening milking is, as a rule, of less duration than that between the evening and morning milking. The shorter the interval, the greater the proportion of total solids. This particularly applies to the proportion of fat.

Period of Milking.—Moreover, the character of cow's milk, as of human, materially depends upon whether the milk withdrawn is from a full mammary gland or from one nearly empty. Reisch and Peligot analyzed the first, second, and third portions of the milk of the ass and of the cow. They found that at the end of milking there was an increase in the total solids, and that this was due to an increase to some extent in the proteids, but chiefly in the fat. Harrington's analyses of the 'fore milk,' 'middle milk,' and 'strippings' illustrate the same fact:

	Fat.	Total Solids.	Water.	Mineral Matter.
'Fore milk' -	3·88	13·34	86·66	0·85
'Middle milk' -	6·74	15·40	84·60	0·31
'Strippings' -	8·12	17·13	82·87	0·82

The milk drawn first from the udder is thus demonstrably deficient in fat and total solids when compared with that last drawn. Boussingault, dividing the period of milking into arbitrary portions and analyzing each specimen, arrived at the following figures, which clearly show the comparative richness of the later portions:

	I.	II.	III.	IV.	V.	VI.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Total solids	10·47	10·75	10·85	11·23	11·63	12·67
Fat	1·70	1·76	2·10	2·54	3·14	4·08
Solids-not-fat	8·77	8·99	8·75	8·69	8·49	8·59

Cow's milk is, thus, far from being a product of stable and uniform quality. Many other factors—notably, the precise character of the diet—have great influence on the character of the milk yielded by the cow. In reference to infant feeding these points are of the greatest importance. No attempt at accurate graduation of cow's milk to the needs of the infant can be successful when the prime material is an unknown quality. In the milk laboratory the standardizing of the milk forms one of the elementary procedures, without which the results would necessarily be vitiated.

Colostrum.—Before and after parturition, *colostrum* is yielded by the cow. Its specific gravity is from 1046 to 1079, and its average composition is as follows:

	Per Cent.
Fat	3·37
Sugar	2·48
Total albuminoids	20·68
Mineral matter	1·78
Water	71·69

Houdet analyzed the milk of the cow in relation to parturition, and the changes were found by him to be as in the following table:

	Fat.	Sugar.	Soluble Proteids.	Colloidal Proteids.	Calcium Phosphate.	Other Salts.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Six days before calving -	0·50	2·35	0·47	17·43	0·44	0·36
Four days before calving -	3·01	3·17	0·45	12·08	0·47	0 40
Immediately after calving -	3·14	2·70	0·25	14·53	0·46	0·42

Richmond's figures illustrate the gradual transition from colostrum to normal milk:

CHANGE OF COLOSTRUM TO NORMAL MILK.

	Fat.	Sugar.	Soluble Proteids.	Colloidal Proteids.	Calcium Phosphate.	Other Salts.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Immediately after calving - -	5·69	3·30	0·51	14·05	0·51	0·54
1 day after calving	4·48	4·05	0·93	5·21	0·43	0·43
2 days „ „	5·70	4·32	1·98	3·52	0·43	0·45
3 „ „ „	7·40	4·26	2·41	3·45	0·43	0·40
4 „ „ „	3·20	4·44	0·56	5·20	0·40	0·30
6 „ „ „	4·20	4·64	1·19	4·02	0·38	0·29
8 „ „ „	4·10	4·96	0·48	3·56	0·40	0·30
14 „ „ „	3·85	5·03	0·58	3·74	0·35	0·36

In connection with these figures, it is scarcely necessary to point out that colostrum milk is quite unsuitable for use as milk for any purpose. In relation to infant feeding, no milk should be used from a cow that has recently calved until several analyses have shown that the colostrum element has completely disappeared.

Milk of other Animals.—Reference may here be made to the milks of certain other animals, as these have occasionally been used for infant feeding. The figures for the ass, goat, and mare are, approximately, as follows:

	Ass. Per Cent.	Goat. Per Cent.	Mare. Per Cent.
Fat	0·36	4·63	1·17
Lactose	4·94	4·22	6·89
Proteids	1·30	4·35	1·84
Mineral matter	0·30	0·76	0·30
Water	93·10	86·04	89·80
	100·00	100·00	100·00

Of these, ass's milk has been, to some extent, made use of for delicate infants. With our present knowledge, it is quite unnecessary, and, indeed, altogether inadvisable, to make use of the milk of any of these animals. If a milk of a composition similar to that of ass's milk be desired, it is quite easy to obtain one from the laboratory so that the precise composition of the mixture is known, and this can be further exactly modified and increased or decreased in strength, according to the requirements of the case. It is therefore unnecessary to discuss these milks.

Difference between Human and Cow's Milk.—The constitution of cow's milk is widely different from that of human milk, and it is necessary that these differences be sufficiently appreciated. The reaction of cow's milk is generally acid, and in order to counteract this some alkali must be used. This is the only foreign body introduced into cow's milk where the laboratory methods of feeding are adopted. The alkalinity may also be obtained by means of lime-water, bicarbonate of soda, or phosphate of soda. The mineral salts are, however, already in excess in cow's milk, so that the addition of these salts can scarcely be regarded as beneficial, though, when administered in minute quantities, the author is not acquainted with any harmful results following their use.

Correction of Acidity.—Lime-water answers the purpose extremely well. Harrington experimented on cow's milk twenty-four hours old to determine the amount of lime-water necessary to counteract the acidity without causing excess of alkalinity. His results were as follows:

Amount of Lime-water in Mixture.	Reaction.
25 per cent.	Strongly alkaline.
12·5 per cent.	Still strongly alkaline.
6·25 per cent.	Slightly alkaline, corresponding to human milk.

This last percentage was, therefore, proved to be the amount necessary to produce an alkaline reaction of the requisite degree. At the same time, when cow's milk is collected under the special precautions to be described later, the acidity of the milk is much less. It has already been pointed out that the reaction, on leaving the udder, is amphoteric and that marked acidity only develops when the milk is allowed to remain under comparatively unhygienic conditions. At a temperature of 65° F. the acidity speedily develops; at 40° F. the development is nil. This acidity thus represents the degree of bacteriological development. In milks modified at the laboratory, 5 per cent. of lime-water is usually quite sufficient, and a greater percentage than this is never called for, unless the condition of the infant constitutes an indication for increased alkalinity.

Specific Factors requiring Adjustment.—The amount of fat present in human and in cow's milk is, practically speaking, the same, and we may usually regard this as 4 per cent. But, in the graduation of the proteid, the fat percentage is inevitably seriously diminished, and, as fat is of extreme importance in regard to general nutrition, the method of modification adopted must be such as to allow for the supply of the full amount of fat required by the infant.

The lactose in cow's milk is much less than that in human milk, and, for the same reason, the amount becomes still further reduced when the milk is diluted. This fact calls for the addition of the requisite amount. Unfortunately, the generic term 'sugar' has led to the use of bodies never found either in human milk or in that of any animal. Cane-sugar, maltose, dextrose, etc., have

physiological and chemical reactions of their own, very definitely distinguished from those of lactose.

The following table summarizes the differences of chemical constitution between human milk and cow's milk:

	Human Milk.	Cow's Milk.
	Per Cent.	Per Cent.
Fat	4·00	4·00
Lactose	7·00	4·75
Total nitrogenous matter	2·00	4·00
Mineral salts	0·25	0·75
Water	86·75	86·50
Reaction	alkaline	acid

Cow's milk thus contains twice as much nitrogenous matter as human milk. But by far the greatest amount of this is present in the form of caseinogen, while the proportions of lactalbumin and the extractives are relatively low. In human milk, the lactalbumin and the extractives predominate. On the addition of acids to cow's milk, large bulky curds are formed. This coagulation, in the case of human milk, is very slightly marked, and the curd is small and flocculent. Rennin produces but little result on human milk, so far as the formation of curd is concerned.

The adjustment of the albuminoid content therefore constitutes the crux of the problem. Not only is the albuminoid content of cow's milk far greater than that of human milk, but the relative proportions of the albuminoids are reversed.

Character of Milk Proteids—Caseinogen.—The two chief proteids present in cow's milk are caseinogen and lactalbumin; lactoglobulin is only present in slight traces, and does not require separate consideration. Caseinogen is present in great amount, and constitutes about 75 per cent. of the total proteids. It is coagulated by the rennin ferment, and the term 'casein' is applied to this precipitated form. This coagulation is directly affected

by the presence of calcium salts; in either the absence or excess of these, precipitation does not occur. It is, however, an interesting fact that, although precipitation does not occur in the absence of calcium salts, the action of rennin produces a distinct change, so that, if the ferment is killed by heat after being allowed to act on milk, and calcium salts are then added to the milk, coagulation immediately occurs. From this it may be assumed that the change wrought by rennin is essentially the same whether the lime salts be absent or present, but that the insoluble form of the changed product only occurs as a result of its combination with calcium. It is asserted by several observers, with considerable probability, that all the proteids of milk exist in combination with mineral salts.

Caseinogen is not coagulated by heat, but it is coagulated by acetic acid in small amount, and becomes soluble in the presence of an excess of the acid. It is precipitated from neutral solutions by the sulphates of ammonium and magnesium in saturated solution.

Lactalbumin.—Lactalbumin in its reaction is quite distinct from caseinogen. It coagulates at a temperature between 165° and 183° F. It is not coagulated either by dilute acetic acid or by rennin. Magnesium sulphate in saturated solution does not cause precipitation, though this results when ammonium sulphate is present in saturated solution.

In the modification of cow's milk for infant feeding it is necessary that the method adopted be one allowing of the elimination of the excessive caseinogen whilst securing the presence of the whey proteids in sufficient amount.

Adjustment of Cow's Milk.—The method of eliminating the excess of caseinogen requires especial consideration. No method of mere dilution can do anything to correct this serious fault. It is, of course, possible by dilution to so reduce the amount of caseinogen present in the

mixture that it is tolerated by the digestion of the infant. But this can, obviously, only be done at the expense of the general nutrition and development of the infant. By this method, the appetite is more or less assuaged while the physiological demands are totally neglected.

Chemical analysis clearly shows the differentiation between albumin and caseinogen. But it is much to be doubted whether these results may be regarded as showing the true proportion between these constituents. It has been shown that the condition in which the albuminoids exist is a very delicate one, easily susceptible of chemical changes likely to defeat the object of the analyst. And it must further be remembered that the methods of analysis, in regard to these complex organic substances, cannot be compared in exactitude and precision with the methods used for detecting the presence of, and estimating the amount of, inorganic substances—such, for instance, as arsenic.

Clinical Factors of Adjustment.—In this respect, clinical and practical evidence is of great value. As the result of considerable experience in the adjustment of the proteid content to dietetic and nutritional requirements, the author is confident that the adoption of the standard of human milk which has been propounded will lead to satisfactory results, when the food mixtures are intelligently adjusted to the needs of the individual infant. For quite young infants—*i.e.*, for those under six weeks of age—the proportion of whey proteids (lactalbumin, lactoglobulin, etc.) to caseinogen should be as 3 to 1. From this period to four months of age the proportion may be gradually adjusted, so that at or about the age of five months discrimination between the albuminoids becomes unnecessary. This practical experience is supported by chemical analysis, for it has been clearly shown that the proportion of caseinogen relative to lactalbumin is much increased in the later stages of human lactation.

The Nitrogenous Extractives.—When caseinogen is precipitated so as to form the insoluble casein, the fluid remaining contains the soluble proteids, lactose and the mineral salts, together with bodies such as hypoxanthin, lecithin, creatin, creatinin, cholesterin, etc. The extractives are present in much larger proportion in the early months of human lactation. The use of whey, therefore, as the diluent, in contrast with water, is by no means confined to its effect in adjusting the albuminoids.

Influence of Extractives on Nutrition.—While we cannot, at present, state with precision the exact function of these organic bodies in the milk plasma, there can be no question that they play an important rôle in the nutrition of the infant. As his cases have accumulated, the author has been much struck by the contrast between young infants fed on mixtures containing a considerable amount of whey and those fed on mixtures where the dilution has been accomplished by means of water. Taking only those cases where the infant has digested the milk - water mixture and has regularly gained weight, and eliminating all those where serious gastric or other disturbance has intervened, the contrast is still marked.

The *active* health, the excellent colour, the bright and happy condition, of the infants on accurately graduated mixtures containing the bodies present in the whey are most noticeable features. These characteristics of choice development are seldom seen in the infant merely supplied with the absolute essentials of physiological nutrition, but deprived of those elements necessary to perfect metabolism.

Practical Effects of Defective Composition.—The total solids of milk in all animals is relatively small, and when these are separated into their several constituents the figures appear insignificant; so that the reader unversed

in the full technical details is perhaps inclined to regard elements which only amount to about ·60 per cent. as bodies almost negligible, and not at all likely to be of any real practical interest.

In the diet of the infant these fractional percentages are of very great importance. Any error is enormously multiplied by the fact that, in contrast with the adult, the infant's food is of precisely the same nature at each meal, except for the variations of composition necessary from time to time.

A deficiency of 1 per cent., for instance, of fat means a serious deprivation to the infant. If an infant is taking 40 ounces of a modified milk per diem, and this mixture contains less fat than it should, and the amount of fat deficient is 1 per cent. of the whole mixture, then the infant is deprived of nearly half an ounce of *pure fat* in a single day. Such a deficiency, continued over weeks and months, cannot but produce serious effects.

The same point may be well illustrated by comparing two prescriptions precisely the same, with the exception that in one, the whole proteids are used, in the other, the proteids are divided:

I.	Per Cent.
Fat - - - - -	3·00
Lactose - - - - -	6·00
Proteids - - - - -	1·00
Lime-water - - - -	5·00

II.	Per Cent.	
Fat - - - - -	3·00	
Lactose - - - - -	6·00	
Whey proteids - - - -	0·75	1·00
Caseinogen - - - -	0·25	
Lime-water - - - -	5·00	

When these prescriptions are translated into actual mixtures, their difference is much more striking than their similarity, as will be seen by the subjoined figures:

	Mixture in accordance with Prescription I.		Mixture in accordance with Prescription II.
Cream 16 per cent. -	3¾ oz.	-	3¾ oz.
Fat-free milk - -	2¼ "	-	½ "
Lime-water - -	1 "	-	1 "
Whey - - -	Nil -	-	14¾ "
Distilled water - -	13 oz.	-	Nil
	20 oz.	-	20 oz.
Added lactose - -	7½ dr.	-	2½ dr.

The use of whey in the substitute feeding of young infants would therefore appear to be essential to perfect nutrition. For many years Dr. Henry Ashby, of Manchester, has been the most prominent advocate in this country of the great value of whey in relation to infant feeding, and his conclusions and practice have been fully confirmed by the author's experience.

Having thus summarized the main factors affecting the problem of modifying cow's milk so as to meet the requirements of the human infant, it is necessary to discuss in detail the practical methods by which this adaptation is best accomplished.

CHAPTER IV

SUBSTITUTE FEEDING—PREMATURE INFANTS—THE DIET OF LATER INFANCY

Substitute Feeding.

In relation to infant feeding, it is necessary to make our terminology as exact as possible, to avoid confusion of thought and expression. The only natural method of feeding the young infant is by maternal nursing, and this method is to be preferred to any other, under favourable circumstances. Certain other methods are available, and fall into two classes—those by which the infant is supplied with milk from another woman or from some animal after modification to adapt it to the infant's digestion, and those by which an infant is fed on preparations artificially manufactured from milk or from other products.

There is no essential distinction to be drawn between wet-nursing and feeding by modified cow's milk; for though maternal nursing must rightly be regarded as the only natural method, there is no justification for regarding breast-nursing by another woman as natural. It would be an assumption far from being justified by the facts that the milk of a wet-nurse necessarily meets the requirements of the infant. On the other hand, the term 'artificial' can scarcely be applied with accuracy either to wet-nursing or to those methods of modifying cow's milk which consist in providing a food as closely approximating to the natural food and its natural conditions as our present knowledge permits. For these methods the term *substitute feeding*

appears to be the most suitable. The term *artificial feeding* is here reserved for those methods of feeding where the food mixtures are derived from products artificially prepared by manufacturers. This practice is only to be justified on grounds of temporary emergency, where neither natural nursing nor any form of substitute feeding is available. It is only under very exceptional circumstances that such cases arise, and therefore, in general, artificial feeding may be regarded as synonymous with improper feeding.

Wet-Nursing.—In reference to the employment of a wet-nurse, it may be said, that this expedient is seldom, if ever, justified where the best methods of substitute feeding are available. The practical difficulties associated with the employment of a foster-mother are unquestionably very great. Her health must be thoroughly sound. Every writer points out, especially, that she must be free from syphilis; but none has ever succeeded in showing how this disease may with certainty be excluded. In many cases the signs of syphilis may be clearly marked, but in women still capable of infecting the infant they nurse there may be no signs definitely pointing to syphilis, and were one to exclude every wet-nurse unless it could be definitely proved that the woman was not syphilitic, the number of wet-nurses available would be extremely small. This consideration, having regard to the class from which wet-nurses are drawn in this country, is of critical importance.

Further, the use of a wet-nurse is an expedient which may prove to be attended with excellent results, the milk meeting the infant's requirements, with the consequence that its gain in weight and its general condition are quite satisfactory. In such a case it is clear that the milk provided by the nurse is of a quality required by the infant. But in the selection of a wet-nurse it is practically quite impossible to insure this, and hence this method must be

regarded as experimental and haphazard in its essential features. The possibilities of altering the character of woman's milk are extremely limited when compared with the opportunities of accurately graduating cow's milk.

In connection with wet-nursing, the domestic difficulties are often very great, and it is by no means infrequent to find the infant's life suddenly imperilled by reason of the nurse's misconduct.

In the past, when the methods of modifying milk were arbitrary and the food mixtures were far from being in harmony with physiological requirements, there can be no doubt that the services of wet-nurses were often invaluable; for in many cases infants were quite unable to digest cow's milk so inadequately modified, and the use of a wet-nurse was justified by this fact.

With our present knowledge the position is altogether altered. In accurate adjustment of food to meet the infant's need, in facility and precision, the advantages are now all on the side of modified cow's milk, and only the necessary knowledge and appreciation of the various factors of the individual case are required to enable us to prescribe a mixture based on the standard of human milk and graduated to meet the precise needs and idiosyncrasies of the particular individual.

It need hardly be said that with arbitrary and unscientific methods of milk modification, frequent failures must occur, and the present tendency to make use of a wet-nurse in cases of difficulty is largely due to the use of these methods.

It is still, unfortunately, true that many authorities advocate these traditional methods. The idiosyncrasies of infants vary so greatly that almost any method, however inadequate or unscientific, must succeed in a certain number of cases, and thus provide results which, on superficial examination, appear to afford some justification for unscientific practices. The failures do not receive the

same degree of attention, and are generally ascribed to the condition of the infant.

The didactic methods of adapting cow's milk to infant feeding are almost innumerable. While they are all more or less based on the different constitution of human and cow's milk, these differences are necessarily very incompletely allowed for, and the important factor of exact adaptation to the individual infant is almost wholly absent.

To Rotch, of Boston, we owe the institution of a method enabling the physician to precisely adapt the food of the infant to its peculiar requirements, and at the same time affording him every opportunity of judging the part played by the various constituents of the diet.

Recognising the essentially unscientific character of the traditional methods, he devoted his attention to the real factors of the problem which had for so long been neglected, with the object of arriving at a system by which a milk mixture could be prepared, in the constitution of which the comparative importance of every essential element received due recognition.

The great and lasting value of his work lies in the abolition of all didactic rules and in the provision of an instrument combining clinical elasticity with scientific precision. By the percentage method which he devised, any desired milk mixture can be prescribed so as to contain the various constituents in any proportion required. If the prescribed mixture prove in any way unsatisfactory, it can be adjusted with the greatest delicacy and precision to the needs of the infant. With splendid energy, Rotch has dealt systematically with every phase of the many-sided problem, and the establishment of milk laboratories was due entirely to his efforts.

Laboratory Methods.—In order to provide a milk of suitable character, the first essential is that the handling of the milk from the outset should be conducted with

the greatest precautions, to insure its cleanliness and good quality.

The cows need to be selected with a view to their special suitability for the provision of a milk lending itself as readily as possible to modification. Of the breeds most suitable for this purpose a brief account has already been given (p. 57). Careful examination is made to determine their soundness and absolute health and vigour. The tuberculin test is applied, and the cows are systematically retested every six months. Should any reaction be obtained in the first instance, the cow is not accepted; and if a reaction is obtained later, the cow is immediately isolated, and is removed as soon as practicable.

Care of the Cow.—The cow-house must be constructed with the object of securing that the environment of the animals is perfect in regard to hygiene and sanitation. The ventilation arrangements should insure a continuous supply of fresh air and the free exit of all impurities, without giving rise to draught or to undue lowering of the temperature. The floor must be of impervious material and permit of thorough flushing. No drains of any kind should be under the floor or communicate with the cow-house. The excreta must be carefully and frequently removed, and the complete cleansing of the house should be carried out by flushing with water, thus carrying all filth into gullies outside the house.

The peculiarities of the milch cow require practical study. They must be especially preserved from nervous disturbances. Dogs or other animals should not be allowed near them. The horses on the farm should always be stabled as far away from the cow-house as possible, since certain flies frequent horses and horse manure, and these give rise to danger of contamination of the milk if the horses are at all near the cows.

Their diet must be of the choicest kind, and foods

injuring the character of the milk, such as brewers' grains, turnips, etc., must be rigidly excluded.

Sanitary Precautions.—The precautions with regard to all the details concerned in the handling of the milk require to be of the most systematic character, in order that the milk, both whole and modified, may be bacteriologically pure. Here must be recognised the important distinction between hygienic organisms and non-hygienic organisms. In the former are included those forms which exist in cow's milk under normal conditions, associated with the most perfect cleanliness on the part of all concerned. In the latter are included those organisms arising from defective precautions—from *contamination* of external origin, such as from the barn, the excreta, and from other sources.

It is essential to success that the man in control of the cowmen should be in complete sympathy with the spirit of the methods adopted, and that, as far as possible, all the employés should be encouraged to take an intelligent interest in them. To insure the proper degree of purity, the handling of the milk has to be carried out under strict supervision in order to prevent the wilfulness or carelessness of any one employé neutralizing the efforts of his fellows.

The Farm Buildings.—In the building and arrangements of the new farm of the Walker-Gordon laboratory at Sudbury the author took a close and continuous interest. In addition to the general plan of the building, much careful work was demanded on the part of all concerned to secure the practical execution of the various requirements. This was especially the case in regard to the methods adopted for rapid cooling and in regard to the modifying.

The arrangements are as follows: A cow-house designed to meet the essentials previously described; separating and cooling rooms; refrigerating tanks and machinery for keeping the mixtures cold; and a large

block called the milk-rooms. In the first of these is the boiler, etc.; in the second the bottles are cleansed by machinery. The next is the sterilizing-room, in which all the utensils used on the farm, and the bottles and tubes in which the milk is put up, are sterilized prior to use.

Next to this chamber is the modifying-room. As it is in this room that the modified milks are prepared, special precautions are taken to protect them from contamination. The walls and floor are kept continuously wet by running water. This not only keeps the room cool, but prevents the rising of dust. The various solutions are kept in ice tanks during hot weather, so as to prevent rise of temperature during the time that the modification is being carried out.

Prior to milking, the cows are carefully cleansed, the udder receiving especial attention. The milkers wear sterilized overalls and wash their hands before beginning work. The milk is drawn through sterilized non-absorbent wool into sterilized pails. As each pail is filled, it is transferred (still covered with the cotton-wool) to the separating-room. The milk is quickly passed through the separator, which is driven by machinery, and is then passed over the refrigerating cooler, which immediately reduces the temperature to 40° F. In this way each pail of milk coming from the cow-house is reduced to nearly freezing-point well within the hour.

Cooling of the Milk.—Nothing is more important than this rapid cooling. If milk is allowed to stand at the ordinary temperature, the rate of development of the bacteria is prodigious, whereas at 40° F. it is practically nil. It is this bacterial development *after* milking that needs to be prevented; for in maternal nursing the opportunity for this does not occur.

Modification of the Milk.—When all the materials are practically ice-cold, these are transferred to the modifying laboratory and the various mixtures are prepared in exact

accordance with the prescriptions. The mixtures are heated at any prescribed temperature, or they are not heated at all, according to the precise instructions received. As soon as these procedures have been carried out, the whole of the mixtures are transferred to the refrigerating tanks, where they are kept until collected for delivery.

The Methods of Modification.—The precise methods of modification need to be briefly described. The materials consist of creams standardized so as to contain known percentages of fat, separated milk which is practically fat-free, whey, lactose, distilled water, and lime-water. Other materials, such as pepsin, rennin, sodium chloride, various cereals, etc., are also at hand for use when indicated by the prescription.

As the constitution of the various materials is known, it is merely a matter of mathematical calculation to determine the precise amount of each required for a given percentage mixture. In order, however, to avoid the great waste of time involved in separate calculations for each mixture, tables have been prepared which are in constant use at the laboratory, and which enable the clerk to quickly arrive at the amount of each ingredient required in the mixture. The milk-modifier, therefore, does not work directly from the prescription, but from the translation of it made by the clerk. An illustration of this translation is given on p. 71.

Despatch of the Milk Mixtures.—When the total mixture for each infant for the day has been prepared, it is divided into separate tubes, one for each feeding. The tubes are plugged with cotton-wool and placed in a basket. The tubes of milk are then pasteurized or sterilized, if this has been ordered on the prescription.

In those cases where the milk has to be transported a long distance by rail, the tubes, instead of being placed in a basket, are packed in a special box containing ice in

the centre. In all cases, while the modified milk is at the laboratory awaiting collection, it is kept in the cold-room.

FIG 1.—BASKET CONTAINING A DAY'S SUPPLY OF MODIFIED MILK.

FIG. 2.—ICE-BOX FOR LONG-DISTANCE TRANSIT OF MODIFIED MILK.

When the milk is received in the home, great care should be taken to preserve the milk from all contamination, and

it should be kept cool. When a feed is required for the infant, the milk has only to be warmed and the teat applied to the tube.

The above is a brief sketch of the methods adopted in the Walker-Gordon laboratories. It represents the results of great practical experience of all the important details involved in infant feeding, and the results of these methods, when applied with judgment and knowledge, have been attended with a success of the highest character.

But it must be said that the laboratory does nothing more than provide the medical profession with an extremely efficient instrument. Whether the results in any given case are successful or not entirely depends upon the way in which this instrument is used. It is, of course, obvious that unless the prescribed milk mixture is suited to the physiological requirements of the infant failure must ensue. It is essential that the old rule-of-thumb methods should be entirely given up, and that the exact conditions should be diagnosed with accuracy and precision.

To criticise a laboratory milk on the ground that it does not agree with the infant is as senseless as to blame the chemist for the failure of a medicine dispensed by him in accordance with a prescription. In the adjustment of the diet of the infant, a clear understanding of the essential factors, combined with clinical experience, is of the first importance. While nothing can take the place of clinical observation, there are, however, many points of practical importance in milk-prescribing, and these will be chiefly discussed later.

The Milk Prescription.—The milk prescription should specify clearly the percentage of fat, of lactose, of proteids, and of alkalinity required, the number of feedings, and the amount of each feeding. It should also explicitly state whether the mixture is to be heated or not, and, if it is to be heated, the precise temperature must be indicated.

6

Average Composition and Amount of Each Feed.

Weeks of Life.	Amount fed in Ounces.	Percentages. Fat.	Sugar.	Proteids.
First	1¼	2·00	4·50	0·75
Second	1¾	2·50	5·50	1·00
Third	2	3·00	6·00	1·00
Fourth	2¼	3·00	6·00	1·00
Fifth	2¾	3·25	6·50	1·00
Sixth	3	3·25	6·50	1·25
Seventh	3	3·50	6·50	1·25
Eighth	3¼	3·50	6·50	1·25
Ninth	3½	3·50	6·50	1·25
Tenth	3½	3·50	6·50	1·25
Eleventh	3½	3·50	6·50	1·25
Twelfth	3¾	3·50	6·50	1·25
Thirteenth	3¾	3·50	6·50	1·25
Fourteenth	4	3·50	6·50	1·25
Fifteenth	4¼	3·75	6·50	1·25
Sixteenth	4¼	3·75	6·50	1·25
Seventeenth	4½	3·75	6·50	1·50
Eighteenth	4½	3·75	6·50	1·50
Nineteenth	4¾	3·75	6·50	1·50
Twentieth	4¾	3·75	6·50	1·50
Twenty-first	4¾	3·75	6·50	1·50
Twenty-second	5	3·75	6·50	1·50
Twenty-third	5	3·75	6·50	1·50
Twenty-fourth	5¼	3·75	6·50	1·75
Twenty-fifth	5¼	3·75	6·50	1·75
Twenty-sixth	5½	3·75	6·50	1·75
Twenty-seventh	5½	4·00	6·50	1·75
Twenty-eighth	5½	4·00	7·00	1·75
Twenty-ninth	5¾	4·00	7·00	1·75
Thirtieth	5¾	4·00	7·00	1·75
Thirty-first	6	4·00	7·00	1·75
Thirty-second	6	4·00	7·00	1·75
Thirty-third	6¼	4·00	6·50	1·75
Thirty-fourth	6¼	4·00	6·50	2·00
Thirty-fifth	6¼	4·00	6·50	2·00
Thirty-sixth	6¼	4·00	6·50	2·00
Thirty-seventh	6½	4·00	6·50	2·00
Thirty-eighth	6½	4·00	6·50	2·00
Thirty-ninth	6½	4·00	6·50	2·00
Fortieth	6¾	4·00	6·50	2·00
Forty-first	6¾	4·00	6·50	2·00
Forty-second	7	4·00	6·50	2·00
Forty-third	7	4·00	6·50	2·25
Forty-fourth	7	4·00	6·00	2·50
Forty-fifth	7	4·00	6·00	2·50
Forty-sixth	7¼	4·00	6·00	2·50
Forty-seventh	7¼	4·00	6·00	2·50
Forty-eighth	7¼	4·00	6·00	2·50
Forty-ninth	7¼	4·00	6·00	2·75
Fiftieth	7¼	4·00	6·00	2·75
Fifty-first	7¼	4·00	6·00	2·75
Fifty-second	7¼	4·00	5·50	3·00

The table opposite shows the average amount and composition of mixtures according to the age of the infant, derived from the average of a large number of mixtures prescribed by American physicians. While these figures afford some guide, they cannot be regarded as of any direct assistance in enabling the practitioner to assess the adequate composition or the amount of food required by an individual infant.

In the case of healthy infants the amount at each feeding is usually in excess of that indicated. A vigorous infant at ten months of age often requires 9 ounces at each meal. In other cases, the quantity required may be small, while the requisite proportion of fat and proteids is high.

Division of the Proteids.—In the previous chapter reference has already been made to the important differences between the albuminoids present in cow's milk and in human milk, and also to the great value of whey in respect of the nitrogenous extractives. For young infants the proteids need to be divided, and the amount of the whey proteids and of caseinogen must therefore be definitely specified. In regard to this certain practical points require attention. As whey is obtained by means of the action of the rennin ferment on separated milk, it is always necessary to heat the whey so prepared, otherwise the continued action of the ferment would result in the precipitation of the caseinogen when this was added to the mixture. The temperature of the whey need not be raised above 150° F., as the rennin ferment is killed at about 140° F.

Whey.—White and Ladd[1] published some valuable observations in regard to whey cream mixtures, and their conclusions were as follows:

'By the use of whey as a diluent of creams of various strengths we are able to modify cow's milk so that its

[1] *Philadelphia Medical Journal*, February, 1901.

proportions of caseinogen and whey proteids will closely correspond to the proportions present in human milk. We can in this way render it much more digestible and suitable for infant feeding.

'2. The best temperature for destroying the rennet enzyme in whey is 65·5° C. Whey or whey mixtures should not be heated above 69·3° C. in order to avoid coagulation of the whey proteids. The percentage of whey proteids in the whey obtained by us was 1 per cent., while in the analysis of the whole milk, approximately three-quarters of the total proteid was caseinogen and one-quarter was whey proteid.

'3. On the basis of these analyses we were able to obtain whey-cream mixtures, with a maximum of 0·90 per cent. and a minimum of 0·25 per cent. of whey proteids in combination with percentages of caseinogen varying from 0·25 per cent. to 1·00 per cent.; of fats, from 1·00 per cent. to 4·00 per cent.; of milk sugar, from 4·00 per cent. to 7·00 per cent.

'4. The emulsions of fat in whey, barley-water, gravity cream, and centrifugal cream mixtures, were the same, both in their macroscopic and microscopic appearances. The combination of heat and transportation, such as sometimes occurs in hot weather, partially destroys the emulsion in all forms of modified milk, but this disturbance can be prevented by the simple precaution of keeping the milk cool during delivery.

'5. Whey-cream mixtures yield a much finer, less bulky, and more digestible coagulum than plain modified mixtures with the same total proteids; the coagulum is equalled in fineness only by that of barley-water mixtures. The coagulum yielded by gravity cream mixture and centrifugal cream mixtures is the same in character.'

Laboratory Calculations.—In the construction of a split proteid mixture at the laboratory, the calculations involved are somewhat elaborate. For instance, the

amount of sugar present in the whey and in the cream has to be accurately determined before the percentage can be adjusted by the addition of lactose. This and many other points are provided for by tables in use at the laboratory. But it is necessary to bear in mind certain facts in relation to these combinations.

Fat can only be added by the use of cream. This necessarily contains both caseinogen and lactalbumin; the average composition of a 16 per cent. cream is:

	Per Cent.
Fat - - -	16·00
Lactose - -	4·00
Proteids - -	3·60

With a cream of higher percentage the amount required to provide the specified fat content is necessarily less, and therefore the percentage of caseinogen added to the mixture is correspondingly diminished. The table on p. 86, formulated by Ladd, illustrates the various factors that need to be accurately estimated. Thus, when a maximum amount of whey proteids is required with a minimum amount of caseinogen, the cream used must be in a concentrated form—such, for instance, as 35 per cent. Further, the amount of the total proteids present is definitely limited by the constitution of the whey and cream. This limitation is, however, of no practical disadvantage, since in the early months of the infant's life, when these mixtures are used, a high proteid content is never indicated. The table on p. 87 shows some of the variations permissible.

These tables show how numerous are the possibilities of graduation, yet, by making use of extremely high-percentage cream, the amount of caseinogen may be even further reduced. In the healthy infant this is never necessary, but in cases of inanition and marasmus, or of severe gastro-enteritis, the digestion may be so enfeebled that caseinogen requires to be reduced to the absolute minimum. The

The Practical Composition of Certain Percentage Mixtures.

No.	20-ounce Mixtures. Percentage of—				Ounces of Cream.				Ounces of Fat-free Milk used with Creams of—				Ounces.		Lactose Measure.	Lactose per Cent., without Dry Lactose.
	Fat.	Lactose.	Proteids.	Alk.	10 per Cent.	12 per Cent.	16 per Cent.	20 per Cent.	10 per Cent.	12 per Cent.	16 per Cent.	20 per Cent.	Lime-Water.	Boiled Water.		
1	1·50	4·50	0·25	5	*	*	*	1½	*	*	*	0	1	17½	2	0·33
2	1·50	4·50	0·50	5	3	2½	2	1½	0	½	1	1½	1	16	2	0·61
3	2·00	5·00	0·25	5	*	*	*	2	*	*	*	0	1	17	2¼	0·75
4	2·00	5·00	0.50	5	*	3¼	2½	2	*	0	½	1	1	15¾	2¼	0·73
5	2·00	5·00	0·75	5	4	3¼	2½	2	¾	1½	2¼	2¾	1	14½	2	1·01
6	2·00	5·50	1·00	5	4	3¼	2½	2	1¾	2½	3¼	3⅓	1	13¼	2¼	1·30
7	2·50	5·00	0·50	5	*	*	3¼	2½	*	*	0	¾	1	15¾	2¼	0·73
8	2·50	5·50	0·75	5	*	4¼	3¼	2½	*	¼	1¼	2	1	14½	2¼	1·01
9	2·50	6·00	1·00	5	5	4¼	3¼	2½	1	1¾	2¾	3½	1	13½	2½	1·23
10	3·00	6·00	0·50	5	*	*	3¾	3	*	*	0	¾	1	15¼	2½	0·84
11	3·00	6·00	0·75	5	*	5	3¾	3	*	0	1¼	2	1	14	2½	1·12
12	3·00	6·00	1·00	5	6	5	3¾	3	0	1	2¼	3	1	13	2¼	1·35
13	3·00	6·00	1·25	5	6	5	3¾	3	1¼	2¼	3½	4¼	1	11¾	2¼	1·35
14	3·00	6·50	1·50	5	6	5	3¾	3	2½	3½	4¾	5½	1	10½	2¼	1·91
15	3·00	6·50	2·00	5	6	5	3¾	3	5½	6½	7¾	8½	1	7½	2	2·68
16	3·50	6·00	0·50	5	*	*	*	3½	*	*	*	0	1	15½	2½	3·78
17	3·50	6·00	0·75	5	*	*	4½	3½	*	*	0	1	1	14½	2½	1·01
18	3·50	6·50	1·00	5	*	5¾	4½	3½	*	0	1¼	2¼	1	13¼	2½	1·26
19	3·50	6·50	1·25	5	7	5¾	4½	3½	½	1¾	3	4	1	11½	2½	1·68
20	3·50	6·50	1·50	5	7	5¾	4½	3½	2	3¼	4½	5½	1	10	2¼	2·02
21	4·00	6·00	0·60	5	*	*	*	4	*	*	*	0	1	15	2½	0·78
22	4·00	6·00	0·75	5	*	*	5	4	*	*	0	1	1	14	2½	1·12
23	4·00	7·00	1·00	5	*	*	5	4	*	*	1	2	1	13	2¾	1·35
24	4·00	7·00	1·25	5	*	6¾	5	4	*	¾	2½	3½	1	11½	2½	1·68
25	4·00	7·00	1·50	5	8	6¾	5	4	1	2¼	4	5	1	10	2½	2·02
26	4·00	7·00	2·00	5	8	6¾	5	4	3½	4¾	6½	7½	1	7½	2¼	2·56
27	4·00	7·00	2·50	5	8	6¾	5	4	6¼	7½	9¼	10¼	1	4¾	2	3·20
28	4·00	7·00	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1½	3·88
29	4·00	6·00	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	1	3·88
30	4·00	5·50	3·00	5	8	6¾	5	4	9¼	10½	12¼	13¼	1	1¾	¾	3·88

For 25-ounce mixtures multiply the amount of each ingredient by 1¼
" 30 " " " " " " 1½
" 35 " " " " " " 1¾

For 40-ounce mixtures multiply the amount of each ingredient by 2
" 45 " " " " " " 2¼

* Combination impossible with strength of cream indicated.

THE POSSIBLE VARIATIONS OF MIXTURES WITH DIVIDED PROTEIDS.

Fat.	Whey Proteid.	Caseinogen.	Fat.	Whey Proteid.	Caseinogen.
1·0	0·50	0·25	2·5	0·90	0·60
1·0	0·75	0·25	2·5	0·75	0·75
1·0	0·90	0·25	2·5	0·90	0·75
1·0	0·50	0·50	2·5	0·90	1·00
1·0	0·75	0·50	2·5	0·50	0·25
1·0	0·90	0·50	2·5	0·75	0·25
1·0	0·50	0·60	3·0	0·90	0·25
1·0	0·75	0·60	3·0	0·50	0·50
1·0	0·90	0·60	3·0	0·75	0·50
1·0	0·75	0·75	3·0	0·90	0·50
1·0	0·90	0·75	3·0	0·50	0·60
1·0	0·90	1·00	3·0	0·75	0·60
1·5	0·50	0·25	3·0	0·90	0·60
1·5	0·75	0·25	3·0	0·75	0·75
1·5	0·90	0·25	3·0	0·90	0·75
1·5	0·50	0·50	3·0	0·90	1·00
1·5	0·75	0·50	3·0	0·50	0·25
1·5	0·90	0·50	3·0	0·75	0·25
1·5	0·50	0·60	3·5	0·90	0·25
1·5	0·75	0·60	3·5	0·50	0·50
1·5	0·90	0·60	3·5	0·75	0·50
1·5	0·75	0·75	3·5	0·90	0·50
1·5	0·90	0·75	3·5	0·50	0·60
1·5	0·90	1·00	3·5	0·75	0·60
2·0	0·50	0·25	3·5	0·90	0·60
2·0	0·75	0·25	3·5	0·75	0·75
2·0	0·90	0·25	3·5	0·90	0·75
2·0	0·50	0·50	3·5	0·90	1·00
2·0	0·75	0·50	3·5	0·50	0·60
2·0	0·90	0·50	3·5	0·75	0·60
2·0	0·50	0·60	4·0	0·90	0·60
2·0	0·75	0·60	4·0	0·75	0·75
2·0	0·90	0·60	4·0	0·90	0·75
2·0	0·75	0·75	4·0	0·90	1·00
2·0	0·90	0·75	4·0	0·50	0·25
2·0	0·90	1·00	4·0	0·75	0·25
2·5	0·50	0·25	4·0	0·90	0·25
2·5	0·75	0·25	4·0	0·50	0·50
2·5	0·90	0·25	4·0	0·75	0·50
2·5	0·50	0·50	4·0	0·90	0·50
2·5	0·75	0·50	4·0	0·50	0·60
2·5	0·90	0·50	4·0	0·75	0·60

Any percentage of lactose from 4 to 7 may be obtained with any of the above combinations.

author, in these cases, has frequently found it advisable to reduce the caseinogen as low as 0·15 or 0·10 per cent. As soon as the digestion shows signs of recovery, the normal proportions can be gradually used.

Indications for Specific Adjustment.—The indications for the particular adjustment of the diet are essentially clinical, and depend on a combination of factors varying with each infant, so that it is extremely difficult, if not impossible, to lay down any general rules in this matter. They can best be illustrated, rather than precisely defined, by clinical facts, and in the following chapters these considerations receive attention.

The Various Methods of Infant Feeding.—The author's experience in infant feeding covers a considerable number of cases, and he has had, at one time or another, opportunities of studying almost every method at all commonly used. It is unnecessary to dwell upon his experiences with the '1 in 3' mixtures, with various combinations of whey and cream, such as that devised by Frankland, with other expedients in the shape of milk partially or entirely peptonized, or with the various diluents, such as barley, oatmeal, and rice water. Success or comparative success was, indeed, frequently obtained by the adjustment of the food of the infant by these methods in the light of clinical experience; but the result was always attended with uncertainty, and the lessons to be derived either from success or failure were, in general, too vague and indefinite to be of use in future cases.

The most emphatic condemnation of these traditional methods is to be found in the views of their exponents. Comparatively few have dealt with the problems in a wide and scientific spirit, and most have confined themselves to the advocacy of some favourite mixture. The reader will find a lengthy account of these various methods in Judson and Gitting's work. Amongst others, the views of Biedert, Heubner, Bendix, Henoch, and

Baginsky are quoted, as also are those of Monti, who 'criticises the methods of Heubner, Hoffmann, and Soxhlet,' and advocates two mixtures, one for the first five months of life, and a second for older infants.

Such 'rule-of-thumb' procedures are altogether out of harmony with our present knowledge.

The clinical facts attending substitute feeding, when this is accurately carried out by means of the percentage method, are most striking. The attitude of the physician towards these cases becomes entirely altered, and a subject the most vague and confused becomes precise and scientific.

Cost of Modified Milk.—It must be admitted that the milk mixtures provided on this system are somewhat expensive when the cost is compared with that of the milk mixtures made at home. The numerous precautions in regard to the handling of the milk, and the time and skill involved in the daily preparation for each infant of a milk mixture to accord with the prescription, have to be paid for, and this cost is more than the poorer classes can bear. On the other hand, the cost is by no means prohibitive for others. When milk mixtures are prepared at home so as to at all approach the best available standard, the actual cost of these is more than half the cost of the laboratory milk; while, in many other respects, there is a great saving of time and trouble by reason of the manner in which the laboratory mixtures are delivered at the home of the infant.

It is impossible to deny the advantages of a method which has not only been attended with the greatest success in Rotch's hands, but has been welcomed by the most competent and advanced men in America. The first Walker-Gordon laboratory was established in Boston in 1901, and there are now some twenty such laboratories.

Objections to Laboratory Modifications.—While, however, the expense and the cost of transport and delivery

over long distances must be admitted to be at present an obstacle to the widest use of graduated milk, other objections to the method have been raised by various writers.

One writer, Starr, has found ‘laboratory milk’ unsatisfactory, and he gives various explanations of these results. The destruction of the natural fat emulsion by the separator is regarded as responsible for some of the failures, and he makes the startling statement that he has never seen an infant below the age of ten months who could tolerate a laboratory mixture containing over $1\frac{1}{2}$ per cent. proteids, and that he has often encountered cases where, at the age of two months or more, a percentage of 0·50 proteids was not digested.

Other writers have made objections of a somewhat similar character, and some have drawn attention to the injury caused by pasteurization or sterilization of the milk at the laboratory.

Arguments of this kind indicate a confusion of thought, which is probably responsible for the failures recorded. It is illogical to criticise a laboratory milk because the natural fat emulsion has been disturbed by the separator. Cream obtained by means of the separator is not a necessary feature of a laboratory milk; those who think that gravity cream is preferable have only to prescribe this. Every physician of experience is acquainted with cases of disordered digestion where the amount of proteids has to be much diminished at first; but Starr's statements suggest that the adjustment of the other constituents must have been at fault, or that, in some respect, there must have been some serious error in the amount or character of the mixtures prescribed.

Were it a fact that infants at nine months of age could not tolerate over $1\frac{1}{2}$ per cent. of proteids, this would certainly constitute a most serious objection to the use of laboratory milk. In the author's experience, the objection

is entirely fallacious, and he has never had the slightest difficulty in providing a healthy infant with the full amount of proteids required. It is difficult to understand how a 'laboratory' mixture can differ, in this respect, from milk mixtures made at home. Surely, the fact that the proteid content is accurately known by the physician does not disturb the infant's digestion.

Separator Cream and Gravity Cream.—In reference to cream obtained by the separator, it has been already pointed out that this is by no means an essential feature of modified milk, and can be entirely obviated by ordering the fat percentage to be obtained by means of what is termed gravity cream. As a matter of fat, neither clinical evidence nor physical considerations support the contention that the separator destroys the fat emulsion of the mixture. Rotch has published micro-photographs of human milk, cow's milk, and modified milk, and the fat globules in the modified milk are seen to be evenly suspended in the mixture. The cream rises to the surface by virtue of gravity without other assistance; the action of the separator is only an intensification of gravity, and it is extremely unlikely that any serious alteration in the character of the fat globules can be caused by this machine.

In other respects, the separation of the cream by the machine is much to be preferred. The process tends to remove any impurities in the shape of dirt that may have found access to the milk; this is found in the 'separator slime' remaining in the machine. 'Gravity cream' in the mixture means that it must be much less fresh, owing to the time necessary for the separation of the cream. When milk mixtures have been heated and have been transported over a considerable distance, alteration of the fat emulsion is extremely likely to occur. The combination of heat and transport has a definite effect which has frequently been noticed, and this probably accounts for some of the state-

ments referred to. When the milk is unheated these changes do not occur.

Various objections of a superficial character have been not infrequently mentioned. The following account is an instance of these:

A practitioner determined to try the laboratory milk in the case of his own infant. After a fortnight's 'thorough trial,' as he described it, he gave it up, as the infant had been suffering from indigestion and other disturbances throughout the whole of this period. The infant was fed on unsweetened condensed milk (much diluted), as it was stated that this was the only form of cow's milk that it could retain.

The infant was slightly premature and was delicate; its weight at birth was 6 pounds. The first milk mixture taken by the infant contained $1\frac{1}{2}$ per cent. of proteids (undivided) and 4 per cent. of fat. This mixture was formulated by a mistaken adherence to a theoretical standard of human milk. The clinical facts immediately showed that the mixture was entirely unsuitable, but no alteration was made for a week. The various symptoms were treated by dill-water, calomel, peppermint, etc. At the end of a week the proteid content was reduced to 1 per cent., but the full fat content was still retained.

When first seen by the author the infant looked very ill and wan. It weighed but $5\frac{1}{4}$ pounds. Its feet were very cold; it was evidently in pain, and the signs of gastric and intestinal digestion were manifest.

After preliminary treatment, the infant was, for twelve hours, given nothing but a 10 per cent. lactose solution (1 ounce every hour), together with brandy at frequent intervals. It was then fed on a mixture of the following composition:

℞	Per Cent.
Fat - - -	1·50
Lactose - -	5·50
Whey proteids - -	0·50
Caseinogen - -	0·15
Alkalinity - -	10·00

Unheated; ten feeds, each of 2 ounces.

Owing to the deficient vitality of the infant, some difficulty was experienced in keeping it warm, and it was found necessary to swathe the whole of the feet and legs in cotton-wool. Brandy was also given two or three times a day. The infant then made progress, and in four weeks' time was doing well on a mixture according to the following prescription:

℞

	Per Cent.
Fat - - -	3·50
Lactose - -	6·50
Whey proteids - -	0·75
Caseinogen - -	0·25
Lime-water - -	5·00

Unheated; ten feeds, each of 3 ounces.

The above case affords an effective illustration both of the 'failure' and the 'success' of laboratory milk.

Home Modification.—Where for any reason the exact methods of the laboratory are not available, the milk must be modified in the house. Home modification is a practical necessity in some cases at present, though it is to be hoped that, in the course of time, the laboratory methods may become available for a larger class of patients. It must always be remembered, in reference to modifications undertaken at the home of the infant, that the composition of the food mixture from day to day is essentially uncertain, and that the danger to the infant from this fact is by no means small.

Necessary Precautions—Quality of Cream.—Cow's milk, clean and containing the constituents of milk in their right proportion, and containing nothing else, is the first essential. In town and country, nothing is so comparatively rare as the product answering to this description, and it is important that undue weight should not be attached to the representations of the milkman. Further, as all methods of modification at all adequate depend on the addition of cream, etc., it is imperative that the vague term 'cream' be avoided and some name be used indicating the character. Thus, the cream supplied for domestic purposes by the laboratory is known and described as a 35 per cent. cream—that is, a cream combining 35 per cent. of fat. Other creams, such as 16 per cent., can be provided. The precise quality is not so important as the knowledge of the percentage constitution. On the other

hand, the cream supplied from the ordinary dairies appears to vary greatly.

The following table from Rotch shows how uncertain must be the quality of any milk mixture prepared by the addition of cream, unless the precise character of the cream be known. The amount of fat present in the mixture depends entirely upon the quality of the cream employed, and, as has already been illustrated, the proteid-content is correspondingly affected. In a cream of low fat percentage the proteids are in comparatively large amount, and *vice versâ*.

THE CONTENT OF MIXTURES IN RELATION TO THE CHARACTER OF THE CREAM USED.

Percentage of Cream.	Percentage of Fat in Mixture.	Lowest Possible Proteid Content.
10 per cent.	1 per cent.	0·38
10 "	2 "	0·67
10 "	3 "	1·00
10 "	4 "	1·34
12 "	1 "	0·27
12 "	2 "	0·54
12 "	3 "	0·82
12 "	4 "	1·08
16 "	1 "	0·20
16 "	2 "	0·40
16 "	3 "	0·60
16 "	4 "	0·80
20 "	1 "	0·15
20 "	2 "	0·31
20 "	3 "	0·46
20 "	4 "	0·62

In regard to the sugar that requires to be added, this should always be in the form of lactose. There is no difficulty in obtaining a supply of this constituent at a reasonable cost, and as it keeps indefinitely, there is no excuse for the use of cane-sugar or other noxious material.

An important practical point also needs attention in respect of those mixtures calling for the use of whey. In the laboratory this is always prepared from separated milk which contains but a trace of fat (0·13 per cent.). When

whey is prepared from *whole milk* the fat percentage is about 2 per cent. Having regard to the delicate calculation involved when whole milk is used, it is much better to use fresh separated milk for the preparation of the whey, and to obtain the required fat percentage by the addition of cream. The *lower* the proteid content of the mixture, the *higher* the fat percentage of the cream should be in order to avoid adding excess of proteids.

The following table gives the percentage composition of mixtures most frequently used, together with their translation into the actual amounts of each ingredient. Where the laboratory cannot be used, these figures may be of service in enabling a mixture to be prepared the percentage composition of which may be approximately known.

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION.

I.

	Per Cent.		
Fat	1·00	32% cream	½ oz.
Lactose	5·00	20% solution	3 ,,
Whey proteids	0·50	Whey	8½ ,,
Caseinogen	0·15	Fat-free milk	¾ ,,
Alkalinity	5·00	Lime-water	1 ,,
		Distilled water	6¼ ,,
			20 oz.

II.

Fat	2·00	32% cream	1¼ oz.
Lactose	6·00	20% solution	4 ,,
Whey proteids	0·50	Whey	8¼ ,,
Caseinogen	0·15	Fat-free milk	½ ,,
Alkalinity	5·00	Lime-water	1 ,,
		Distilled water	5 ,,
			20 oz.

III.

Fat	2·00	32% cream	1¼ oz.
Lactose	6·50	20% solution	3½ ,,
Whey proteids	0·60	Whey	12 ,,
Caseinogen	0·20	Fat-free milk	5 dr.
Alkalinity	5·00	Lime-water	1 oz.
		Distilled water	1⅝ ,,
			20 oz.

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued.*

IV.

	Per Cent.		
Fat -	2·00	32% cream -	1¼ oz.
Lactose -	6·50	20% solution -	3½ "
Whey proteids -	0·75	Whey -	13¼ "
Caseinogen -	0·25	Fat-free milk -	¾ "
Alkalinity -	5·00	Lime-water -	1 "
		Distilled water -	2 dr.
			20 oz.

V.

Fat -	2·00	32% cream -	1¼ oz.
Lactose -	6·50	20% solution -	3½ "
Whey proteids -	0·75	Whey -	11½ "
Caseinogen -	0·50	Fat-free milk -	2½ "
Alkalinity -	5·00	Lime-water -	1 "
		Distilled water -	2 dr.
			20 oz.

VI.

Fat -	2·50	32% cream -	1¾ oz.
Lactose -	6·50	20% solution -	4½ "
Whey proteids -	0·50	Whey -	7¾ "
Caseinogen -	0·25	Fat-free milk -	¾ "
Alkalinity -	5·00	Lime-water -	1 "
		Distilled water -	4¼ "
			20 oz.

VII.

Fat -	2·50	32% cream -	1¾ oz.
Lactose -	6·50	20% solution -	3½ "
Whey proteids -	0·75	Whey -	13 "
Caseinogen -	0·25	Fat-free milk -	¾ "
Alkalinity -	5·00	Lime-water -	1 "
			20 oz.

VIII.

Fat -	3·00	32% cream -	2 oz.
Lactose -	6·50	20% solution -	3½ "
Whey proteids -	0·75	Whey -	12¾ "
Caseinogen -	0·25	Fat-free milk -	¼ "
Alkalinity -	5·00	Lime-water -	1 "
		Distilled water -	4 dr.
			20 oz.

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued*.

IX.

	Per Cent.		
Fat - - -	2·00	16% cream -	$2\frac{1}{2}$ oz.
Lactose - -	6·50	20% solution -	$5\frac{1}{4}$,,
Proteids - -	1·00	Fat-free milk -	$2\frac{3}{4}$,,
Alkalinity - -	5·00	Lime-water -	1 ,,
		Distilled water -	$8\frac{1}{2}$,,
			20 oz.

X.

Fat - - -	2·00	16% cream -	$2\frac{1}{2}$ oz.
Lactose - -	6·50	20% solution -	$4\frac{1}{2}$,,
Proteids - -	1·25	Fat-free milk -	4 ,,
Alkalinity - -	5·00	Lime-water -	1 ,,
		Distilled water -	8 ,,
			20 oz.

XI.

Fat - - -	2·00	16% cream -	$2\frac{1}{2}$ oz.
Lactose - -	6·50	20% solution -	$4\frac{3}{4}$,,
Proteids - -	1·50	Fat-free milk -	$5\frac{1}{4}$,,
Alkalinity - -	5·00	Lime-water -	1 ,,
		Distilled water -	$6\frac{1}{2}$,,
			20 oz.

XII.

Fat - - -	2·50	16% cream -	$3\frac{1}{4}$ oz.
Lactose -	6·50	20% solution -	5 ,,
Proteids -	1·25	Fat-free milk -	$3\frac{1}{2}$,,
Alkalinity -	5·00	Lime-water -	1 ,,
		Distilled water -	$7\frac{1}{4}$,,
			20 oz.

XIII.

Fat - -	2·50	16% cream -	$3\frac{1}{4}$ oz.
Lactose -	6·50	20% solution -	$4\frac{3}{4}$,,
Proteids	1·50	Fat-free milk -	$4\frac{3}{4}$,,
Alkalinity - -	5·00	Lime-water -	1 ,,
		Distilled water -	$6\frac{1}{4}$,,
			20 oz.

XIV.

Fat - -	3·00	16% cream -	$3\frac{3}{4}$ oz.
Lactose -	6·50	20% solution -	5 ,,
Proteids -	1·25	Fat-free milk -	3 ,,
Alkalinity	5·00	Lime-water -	1 ,,
		Distilled water -	$7\frac{1}{4}$,,
			20 oz.

PRESCRIBED MIXTURES AND THEIR ACTUAL COMPOSITION —*continued.*

XV.

	Per Cent.		
Fat	3·00	16% cream	3¾ oz.
Lactose	6·50	20% solution	4¾ "
Proteids	1·50	Fat-free milk	4¼ "
Alkalinity	5·00	Lime-water	1 "
		Distilled water	6¼ "
			20 oz.

XVI.

Fat	3·50	16% cream	4½ oz.
Lactose	6·50	20% solution	4¾ "
Proteids	1·50	Fat-free milk	3½ "
Alkalinity	5·00	Lime-water	1 "
		Distilled water	6¼ "
			20 oz.

XVII.

Fat	4·00	16% cream	5 oz.
Lactose	6·50	20% solution	5 "
Proteids	1·25	Fat-free milk	1¾ "
Alkalinity	5·00	Lime-water	1 "
		Distilled water	7¼ "
			20 oz.

XVIII.

Fat	4·00	16% cream	5 oz.
Lactose	6·50	20% solution	4¾ "
Proteids	1·50	Fat-free milk	3 "
Alkalinity	5·00	Lime-water	1 "
		Distilled water	6¼ "
			20 oz.

XIX.

Fat	4·00	16% cream	5 oz.
Lactose	7·00	20% solution	4½ "
Proteids	1·75	Fat free milk	4¼ "
Alkalinity	5·00	Lime water	1 "
		Distilled water	6¼ "
			20 oz.

XX.

Fat	4·00	16% cream	5 oz.
Lactose	7·00	20% solution	4¾ "
Proteids	2·00	Fat-free milk	5½ "
Alkalinity	5·00	Lime-water	1 "
		Distilled water	3¾ "
			20 oz.

Ashby's Method.—In those cases where such adjustments cannot be carried out, Ashby's method may be recommended.[1]

A 30-ounce bottle is filled with fresh milk, plugged with cotton-wool, and placed in an ice-chest or as cool a place as possible for five hours. The lower half is siphoned off and replaced with an equal quantity of 7 per cent. lactose solution. This is heated at 160° F. for thirty minutes, cooled rapidly, and kept at a low temperature. With good milk this mixture will contain, on the average, 1·8 per cent. proteids, from 3 to $3\frac{1}{2}$ per cent. fat, and 6 per cent. lactose. For young or delicate infants a weaker mixture may be made by siphoning off the lower two-thirds of the milk and adding 5 per cent. sugar solution. The mixture should always be rendered alkaline by the addition of sodium bicarbonate or a saturated solution of lime.

By some such methods it is undoubtedly possible to rear infants who are vigorous and healthy. A very large proportion of failures must inevitably occur by reason of the inexact methods, and many young and delicate infants are reared on foods altogether inadequate in consequence of their inability to deal with the ordinary mixtures made with cow's milk. Hence various expedients are tried, and one of the commonest is the use of condensed milk or the extreme dilution of cow's milk. Though these may succeed to the extent that the infant's digestion is no longer disturbed, this success can only be gained at the expense of its health and development. In all such cases the importance of adequate feeding should be clearly pointed out to the parents, in order that they may have the opportunity of deciding whether or not they are prepared to bear the expense of the more costly but far more efficient method of exact percentage feeding.

[1] 'Diseases of Children.' Ashby and Wright; London, 1900.

Regulations of Substitute Feeding. — The general hygienic principles in regard to substitute feeding are the same as those applying to maternal nursing. The need for regularity in regard to the intervals is, of course, as great in the one as in the other. But the amount to be given to the infant when bottle-fed calls for careful discrimination and judgment. No set rules can be laid down; one infant will require twice as much in amount as another infant of the same age, and the difference of amount may or may not be compensated for by a difference of quality in the substitute food. The table below shows the intervals of feeding and the amount of each feeding at the various ages. The figures are only to be regarded as an approximate guide, and must be adapted in practice to the actual requirements of the infant.

GENERAL RULES FOR FEEDING DURING THE FIRST YEAR.

Age.	Interval.	Number of Feedings in 24 Hours.	Number of Night Feedings.	Amount at Each Feeding.	Total Amount in 24 Hours.
1 week	2 hours	10	1	1 ounce	10 ounces
2 weeks	2 ,,	10	1	1½ ounces	15 ,,
4 ,,	2 ,,	9	1	2½ ,,	22½ ,,
6 ,,	2½ ,,	8	1	3 ,,	24 ,,
8 ,,	2½ ,,	8	1	3¼ ,,	26 ,,
3 months	2½ ,,	7	0	4 ,,	28 ,,
4 ,,	2½ ,,	7	0	4½ ,,	31½ ,,
5 ,,	3 ,,	6	0	5½ ,,	33 ,,
6 ,,	3 ,,	6	0	5¾ ,,	34½ ,,
7 ,,	3 ,,	6	0	6¼ ,,	37½ ,,
8 ,,	3 ,,	6	0	7 ,,	42 ,,
9 ,,	3 ,,	6	0	7 ,,	42 ,,
10 ,,	3 ,,	5	0	8½ ,,	42½ ,,
11 ,,	3 ,,	5	0	8¾ ,,	43¾ ,,
12 ,,	3 ,,	5	0	9 ,,	45 ,,

Especial attention is called for in regard to all the appliances used. The indiarubber teats, after use, should be turned inside out and thoroughly cleansed with boracic acid solution. It is a mistake, however, to keep

them continuously in this solution, as the rubber is much damaged and is more likely to retain particles of decomposing milk. Care also should be taken to see that none of the boracic solution remains on the teat when taken by the infant. To insure this, immediately prior to the feeding the teat should be rinsed in boiled water. It is scarcely necessary to say that bottles fitted with india-rubber tubing are to be totally condemned as altogether unfit for the purpose. The boat-shaped bottle may be used, but by far the most convenient form is that figured in the basket on p. 80. This is more in the shape of a tube than a bottle, and is so termed at the laboratory. It is readily cleansed, and when properly fitted with an appropriate teat there is considerable resistance to the egress of the milk, thus imitating, to some extent, the natural method, and tending to prevent the infant obtaining its food too rapidly, which is one of the common incidents of bottle-feeding.

In reference to the laboratory mixtures, the nurse should be specially cautioned that the full amount prescribed is not to be given, when the infant shows that it is satisfied before the tube is emptied. It is, of course, impossible to dictate to the infant that it shall take precisely the same amount at each feed. But the nurse, in view of the definite amount supplied in each tube, is apt to regard this as an instruction to her to see that the full amount is taken by the infant. This misconception should be specifically guarded against. On the other hand, specific instructions should be given that she is not under any circumstances to increase the amount, or to add anything to the food mixture as supplied, as such procedures may altogether nullify the care taken in preparing the food.

Premature Infants.

The premature infant requires peculiar care and attention. Infants born before the twenty-eighth week of

gestation do not, as a rule, survive for more than a few hours or days, in consequence of their absolute inability to maintain independent life. Cases, however, from time to time occur where infants survive though born considerably before this limit.

During the last three months of pregnancy the development of the fœtus is remarkably rapid, and in cases where the induction of premature labour is necessary the operation should not be performed until the maximum development that is consistent with safety has been attained.

The last fortnight of normal pregnancy is not attended, as a rule, by any marked increase in the size or weight of the infant; or, at least, the rate of development during these fourteen days is not comparable with that of the previous months.

Towards the termination of pregnancy, the fœtus appears to be undergoing a consolidation of tissue, and to be accumulating the power of resistance enabling it to maintain a separate existence. The infant at full term is more fully covered with vernix caseosa, its nails are longer, and it is stronger and more active than the infant born a fortnight before full term. In length and weight no great disparity exists, so that the infant of thirty-eight weeks' gestation of one mother may compare favourably with the healthy infant at full term of another mother.

In all cases of prematurity the two factors requiring persistent attention are the inherent weakness of vitality and the comparative inability to maintain animal heat. The infant should not be bathed, but should be anointed over the whole body with warm oil, and then swathed in cotton-wool that has been previously warmed.

Maintenance of Animal Heat.—The maintenance of the normal heat of the body is so important that, unless this is attained, the infant will almost certainly die. For this purpose an incubator is usually the most practicable method. But it should be remembered that this is only

a means to an end. If the infant's temperature can be maintained without this rigid enclosure, the result is likely to be more satisfactory.

The objections to the incubator are that, despite the most extreme precaution, it is almost impracticable to obtain natural ventilation, and the infant is necessarily subject to sudden changes of temperature when it has to be fed and attended to—occasions which are of exceptionally frequent occurrence. When practicable, a small room should be devoted to the purpose of providing a more natural form of incubator. It should be heated by a coal fire; the temperature of the room should be kept at the required degree, according to the necessities of the case, and a full supply of pure fresh air should be constantly maintained. The infant should also be surrounded by hot-water bottles at its feet and at the sides.

The excessive heat is trying to the nurses, but the natural circulation of air gives to the delicate infant a much better chance of life. Most of the difficulties associated with the abnormal heat of the room are to be surmounted by provisions meeting the necessities. The nurses should abandon ordinary dress, and should be attired in a few light and loose garments. Their changes of duty should be frequent, so that the same nurse is not compelled to remain in the room for more than four hours. Precautions are also necessary to prevent the nurses taking chill from exposure to the external air.

Where it is impracticable to secure a suitably-warmed and adequately-ventilated room, an incubator should be used.

In either case, the temperature should not be kept higher than is necessary to maintain a normal temperature in the infant, and as its age increases the external heat supplied should be gradually reduced, so that the production of animal heat and of vigour is stimulated.

Alcohol is of the greatest value during the first days or weeks of the life of a premature infant. It is usually most efficacious when given in 3 or 5 minim doses (in a teaspoonful of warm water) immediately before feedings.

The Feeding of Premature Infants.—Both in regard to fat and proteids the digestion is extremely weak, and consequently the milk mixture needs to be extremely dilute. The feedings require to be frequent, and the amount at each feed should not at first exceed 1 drachm. The following mixtures illustrate the general character of the food required, the precise composition of the mixture being dependent on the age and conditions of the infant:

℞	Per Cent.	Per Cent.	Per Cent.
Fat	1·00	1·00	1·25
Lactose	3·50	4·00	4·50
Whey proteids	0·25	0·50	0·50
Caseinogen	0·10	0·10	0·25
Lime-water	5·00	5·00	5·00
	24 feeds, each of 1 dr.	24 feeds, each of 1 dr.	12 feeds, each of 2 dr.

As a rule the infant is too feeble to suck, and is generally fed by means of a spoon or medicine-measure. These, however, are not satisfactory, as much of the mixture is spilt. The most convenient form of feeder is a dropper fitted with an indiarubber bulb, such as is used for eye lotions. The food can then be injected into the mouth of the infant, and by this simple expedient much delay and difficulty is saved.

The room which the infant occupies should have a sunny aspect, but the infant itself should be protected from direct light and kept in semi-darkness. The prognosis in regard to premature infants should always be extremely guarded until continuous progress has been made for some time. The vitality is so weak that, despite the utmost care and vigilance, collapse and death are liable to occur. Almost invariably, early deaths are associated with atelectasis or with secondary collapse of the lungs.

The Diet of Later Infancy.

Towards the close of the first year of life, functions are established which are indicative of the infant's first stage of development towards the conditions characteristic of the adult, and in consequence the nature of the diet requires to be adjusted to meet the nutritional need.

The changes should at first be made gradually, so as to avoid digestive disturbance by the sudden alteration of the food. In the latter part of the second year the development of the functions is so rapid in a healthy infant that somewhat radical additions to the dietary become necessary.

While the food at this stage of development does not, as a rule, call for the delicate adjustment so essential when the feeding is in substitution for human milk, it is important that special regard be paid to its general character, so that it is nutritious, is given in suitable form, and, particularly, that injurious materials are rigidly excluded.

Starch.—At about the end of the tenth month, and somewhat earlier in cases of exceptional development, starch in suitable form may be added to the food. The oat-jelly[1] recommended by Rotch is extremely useful for this purpose, as the starch is in a delicate form, and the amount to be given can be easily regulated. The following prescription is frequently used by the author as the means of first introducing starch into the diet:

℞	Per Cent.
Fat - - - -	4·00
Lactose - - - -	7·00
Albuminoids - - -	2·25
Alkalinity - - -	5·00
Oat-jelly - - -	1 ounce.

Six feeds, each of 9 ounces.

[1] Oat-jelly is prepared as follows: Two ounces of coarse oatmeal are allowed to soak in a quart of cold water for twelve hours. The mixture is then boiled down so as to make a pint, and is strained through a fine cloth while it is hot. When it cools a jelly is formed, which is to be kept on ice until needed.

As, in such a mixture, the amount of oat-jelly replaces that amount of added water, the percentage composition of the other elements remains practically the same. When this or a similar mixture is taken well, the amount of starch can be increased, and the composition of the milk can be gradually adjusted to that of whole cow's milk.

Diet in the Second Year.—At the end of the first year bottle-feeding should be abandoned, and bread may be introduced into the diet together with mutton or chicken broth and similar preparations. The form of sugar no longer needs to be confined to lactose, and cane-sugar may replace this. The number of meals should be limited to five, and should be arranged somewhat as follows:

8 a.m.: Bread and milk, prepared from stale bread and whole cow's milk, and sweetened with cane-sugar.

11.30 a.m.: Milk and oat-jelly in equal parts flavoured with a little salt.

Mid-day: Bread with mutton broth, or with gravy pressed from the joint, or with raw-meat juice suitably flavoured. A little mashed potato may be added, but unless the infant is well developed it is wise to postpone this for a month or two.

Evening or late afternoon: Bread and milk.

Raw-Meat Juice. — Raw-meat juice is an extremely valuable method of providing the infant with nourishing and invigorating food. It should be given two or three times in the week, and may be prepared as follows:

Fresh, well-minced steak is mixed with cold water in the proportion of one part of steak to two parts of water, and this is vigorously stirred in order to thoroughly break up the muscle fibres. The mixture, after being allowed to stand for thirty minutes covered up in a cool place, should then be strained through muslin in order to exclude all solid material. This fluid may take the place of the broth or gravy referred to, and if the infant shows distaste for the flavour, a small quantity of one of the meat essences

(such as Liebig's) may be added. The juice may be suitably warmed, but should not be raised to a high temperature; otherwise the proteids are coagulated, and in this condition they are much less digestible.

At the end of the fifteenth month milk puddings, bread-and-butter, potatoes (well baked), may be added to the dietary. The juices of fruits such as oranges, peaches, apricots, and strawberries, are also useful. These are best given in the morning about an hour before the second meal. The juice should be carefully strained so that it is entirely free from pulp or seed.

At eighteen months of age, practically all the simple natural foods are permissible. A quite fresh egg beaten up in milk (whole or diluted) forms an excellent meal with bread or toast. Fish in the shape of plaice, sole or cod, carefully freed from bones and without sauce, soups made from meat and vegetables, chicken, beef and mutton, may all be given. The solid foods must be carefully minced, and may be, with advantage, supplemented by mashed potato, bread and gravy.

Stewed apples and fruit jellies are also useful. It is generally advisable to vary the diet from day to day, in order to prevent the infant forming a dislike for certain articles. All forms of pastry, suet puddings, and the like, must be strictly forbidden. They not only tend to upset the digestion, but create a perverse appetite, from which arises a distaste for the foods most valuable in promoting health and vigour. Throughout the period of active growth fat is an important element in the diet.

CHAPTER V

ARTIFICIAL FEEDING

A VERY large number of patent foods for infants are put forward by manufacturers and are described as the best for infants, the most perfect substitute for human milk, or in similar language, and they are most extensively used. In some cases, they appear to be allowed or recommended by members of the medical profession. It therefore becomes necessary to discuss the relative merits of these preparations, though, as they are so extremely numerous, only a few of the more prominent ones can be dealt with. Those not specifically referred to may be regarded as belonging to one of the groups described below.

Milk Foods.—These foods are all made on a method essentially the same, and include such foods as Carnrick's Soluble Food, Manhu Infant Food, Nestlé's Milk Food, and many others. They are generally prepared from milk condensed, sweetened, and then evaporated to dryness, with the addition of some form of flour partly converted into dextrine.

Of these foods, *Nestlé's Milk Food* is probably the most widely known and extensively advertised. Its percentage composition is given by Hutchison as—

Water.	Proteid.	Fat.	Carbohydrates.	Mineral Matter.
5·5	11·0	4·8	77·4	1·30

More than a third of the carbohydrates is in the form

of starch, and there is 30 per cent. of cane-sugar. It is advertised by the manufacturer as an entire diet for infants, without requiring the addition of milk, and for use 1 ounce is to be mixed with 5 ounces of water.

This preparation is a typical instance of its class, and its defects are so numerous that only the chief points can be given attention. A large proportion of the materials present are pernicious and injurious. They are not found in either human milk or cow's milk. Cane-sugar is highly objectionable, while starch should never be part of an infant's diet during, at any rate, the first six months of life. These foods all show a great excess of carbohydrates, largely consisting of starch, while they are deficient in the requisite food materials. When the food is mixed with water, according to the directions, the fat amounts to less than 1 per cent.

Allenbury's Food (*No.* 1).—This is a desiccated cow's milk from which the excess of casein has been removed and some soluble *vegetable* albumin, milk-sugar and cream added. No starch appears to be present. Its percentage composition is—

Water.	Proteid.	Fat.	Carbohydrates.	Mineral Matter.
5·7	9·7	14·0	66·85	3·75

For an infant of three months, ½ ounce is to be added to 3 ounces of water. The same excess of carbohydrates is to be noted (though in this case starch is absent), and the fat is deficient.

There are very many objections to the preparation, but, when compared with the very low standard necessarily occupied by dried preparations, this seems to be the most adequate, since it is free from pernicious foreign matter, such as starch, while it contains a comparatively high (though still deficient) percentage of fat. Its use can only be justified when neither fresh milk nor good condensed milk can be obtained. Under very exceptional circumstances, the use of some dried preparation may be un-

avoidable. In such cases this form may be recommended as the least harmful.

Horlick's Malted Milk is a mixture of desiccated milk (50 per cent.), wheat flour (26·25 per cent.), barley malt (23 per cent.), and bicarbonate of soda (0·75 per cent.). Its percentage composition is—

Water.	Proteid.	Fat.	Carbohydrates.	Mineral Matter.
3·7	13·8	9·0	76·8	2·70

There is no starch, but a very large proportion of the carbohydrates consists of maltose—a highly undesirable feature. When mixed with water in the proportion of three teaspoonfuls to 4 ounces, the proportion of fat is very deficient. The proteids are also very deficient.

Mellin's Food is prepared from barley and wheat flour, which is converted by diastase into soluble carbohydrates, of which more than half is glucose. It is, practically, little more than sugar in various forms, there being, however, no lactose present. Hutchison states that it may be regarded as a desiccated malt extract. Its percentage composition is—

Water.	Proteid.	Fat.	Carbohydrates.	Mineral Matter.
6·3	7·9	*a trace*	82·0	3·8

It differs entirely from the previous preparations in being intended by the manufacturers merely as an adjuvant to milk. For an infant under three months the mixture recommended is half a tablespoonful to $\frac{1}{4}$ pint of milk and $\frac{1}{4}$ pint of water. The manufacturers publish several tables for 'modifying' milk by the use of cream, milk, and the 'food.' Inasmuch as all the good features of these mixtures arise from the milk and cream, and the objectionable features from the presence of the food, these modifications have little to recommend them. Where fresh milk and cream are obtainable, it is entirely unnecessary to use this or any other food.

Owing to the great quantity of carbohydrates, this food

when mixed with milk is highly fattening, and an infant fed on the mixture is likely to be abnormally fat and flabby, and to show marked signs of rickets and other nutritional disorders. In connection with preparations of this kind, it must be remembered that in use the instructions are apt to be disregarded, and very little or no milk given in the mixture. In such cases, the danger is extreme, and the manufacturers can scarcely be held innocent when they give the name of 'food' to a preparation which is manifestly nothing of the kind.

A very large number of foods (such as Allenbury's Malted Food, Benger's Food, Coombs' Malted Food, Worth's Perfect Food, and many others) are prepared from cereals, and contain malt and pancreatic ferments which convert the starch into soluble substances, dextrine or malt-sugar, when mixed, though, as a rule, a large amount of unchanged starch is present. These are intended to be mixed with cow's milk and water. None of them can be recommended. Hutchison points out that the only elements they supply are carbohydrates, and, to a less extent, proteid.

A further series consists of farinaceous foods in which no alteration has been made in the starch. Among these are Chapman's Wheat Flour, Frame Food, Robinson's Patent Barley and Groats, Ridge's Food, Neave's Food, and there are numerous other forms. The fact that these contain starch renders them entirely unsuitable for infants under the age of nine months, while, when farinaceous food is required, it is certainly preferable that it should be supplied in the form of rusks and the numerous simple preparations, such as oat-jelly, bread-jelly, bread, nursery biscuits, and the like.

Condensed Milk.—Condensed milk is cow's milk from which a large proportion of the water has been removed by evaporation, by means of heat, under a pressure less than that of the normal atmosphere. The milk is generally reduced to one-third of its original volume, so

that only two parts of water require to be added to one part of the condensed milk to restore it to its original composition. Under the term 'condensed milk' are embraced products differing very widely in their composition, these variations being dependent on the character of the milk employed and the presence or absence of cane-sugar. A great number of the condensed milks are made from milk from which the fat has been previously abstracted. Dyer[1] reported on the constituents of seventeen samples, some of which were prepared from milk completely skimmed, while others were prepared from partially-skimmed milk:

PERCENTAGE OF FAT IN CERTAIN BRANDS OF CONDENSED MILK.

1. Marguerite brand	0·42
2. Tea brand	0·48
3. Gondola brand	0·48
4. Cup brand	0·49
5. Goat brand	0·56
6. Calf brand	0·60
7. Wheatsheaf brand	0·62
8. Swiss Dairy brand	0·63
9. Daisy brand	0·69
10. Clipper brand	0·73
11. Shamrock brand	0·79
12. Cross brand	0·96
13. Home brand	1·02
14. Handy brand	1·49
15. Nutrient brand	2·36
16. Cow brand	2·84
17. As You Like It brand	4·23

All such preparations may immediately be dismissed as impossible for the purposes of infant nutrition.

Of the condensed milks made from whole milk there are two varieties—the sweetened and the unsweetened. The following table shows the composition of some of the chief brands of *condensed whole milk* (*sweetened*) :

COMPOSITION OF CONDENSED WHOLE MILK (SWEETENED).

Brand.	Total Solids.	Proteids.	Fat.	Lactose.	Cane-sugar.
Nestlé	77·2	9·7	13·7	15·0	37·2
Rose	76·6	8·3	12·4	17·6	36·1
Milkmaid	76·3	9·7	11·0	14·6	38·7
Full Weight	76·5	12·3	11·0	13·5	37·2
Anglo-Swiss	74·4	8·8	10·8	16·0	37·1

[1] *British Medical Journal*, July 27, 1895.

The added cane-sugar is a very great defect. Not only is the cane-sugar itself inimical to the infant, but the great sweetness precludes the milk being modified so as to result in the mixture containing anything approaching to the normal proportions of fat and albuminoids.

Dilution of Condensed Milk.—To restore the milk to normal, so far as the fat and proteids are concerned, only two parts of water to one of milk would be required. But dilutions as weak as one of milk to fourteen of water are recommended, in order to counteract the difficulty of the excessive sweetness. Pearmain and Moor have pointed out the effect of these dilutions.

'The following table shows the character of the liquid —it cannot be called milk—that is produced by following out the directions on the labels of half a dozen of the *best brands of (sweetened) whole-cream milk*':

Sweetened Whole Milk.	Dilution recommended for Infant's Use.	Fat in such Product.
A	1 to 5	1·8
B	1 „ 14	0·7
C	1 „ 14	0·6
D	1 „ 15	0·7
E	1 „ 14	0·8
F	1 „ 14	0·7
G	1 „ 14	0·7

Holt has published a table showing the composition of specimens of Borden's Eagle brand of condensed milk, and its percentage composition when diluted. The analysis was made by E. E. Smith:

	Condensed Milk.	With 6 Parts of Water.	With 12 Parts of Water.	With 18 Parts of Water.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Fat	6·94	0·99	0·53	0·36
Proteids	8·43	1·20	0·65	0·44
Sugar {Cane, 40·44; Milk, 10·25}	50·69	7·23	3·90	2·67
Salts	1·39	0·17	0·10	0.07
Water	31·30	90·49	94·82	96·46

Unsweetened Condensed Milk. — The unsweetened condensed whole-cream milks constitute a very much better form of nourishment for the infant, though when sufficiently diluted they are still deficient in fat. The sugar in these is entirely milk-sugar. The following table shows their percentage composition:

Brand.	Total Solids.	Proteid.	Fat.	Milk-sugar.
Ideal - -	38·0	8·3	12·4	16·0
First Swiss -	36·7	9·7	10·5	14·2
Viking - -	34·2	9·0	10·0	13·3
Hollandia -	43·0	11·3	9·8	18·5

The above facts illustrate the most important points in regard to the artificial preparations. They all fail so absolutely in the primal requirements that it is unnecessary to do more than mention a few of the numerous fallacies in connection with this matter.

Proteids.—The term 'proteid' is little more than a generic name for a class of natural products, all resembling each other in being nitrogen-containing bodies, but differing very widely in other respects. In regard to the feeding of infants, it is quite illegitimate for us to use such a wide term without limitation. Two albuminoids, practically, only concern us—the whey proteids (chiefly lactalbumin) and caseinogen. The proteids derived from wheat, from the pea nut, or from numerous other sources, are quite inadmissible.

Carbohydrates.—In reference to the carbohydrates, these include materials widely differing from each other; the only criterion by which a milk preparation for infants is to be judged in regard to carbohydrate is the presence or absence of lactose. Any other form of carbohydrate is a foreign body.

In the light of our present knowledge, the use of these substitutes for milk is deplorable, as it is one of the

greatest factors in the excessive mortality and disease among infants. However greatly various authorities may differ as to the most expedient method of providing the infant with an adequate substitute for human milk, all of them are united in their condemnation of these dried and condensed preparations.

Hutchison, referring to condensed milk, states: 'There can be no doubt that an immense amount of harm is done to infants by the indiscriminate use of such milks. Babies fed on them may look fat enough, but they are pale and flabby, and often suffer from rickets; for fatness produced by abundance of sugar in the milk is, as has been already pointed out, by no means a sure indication of health, and the pictures of such fat but flabby infants so freely spread abroad by the makers of condensed milks are very deceptive.' No proprietary food possesses any real advantage over the best brands of condensed milk, and they should all be avoided as complete foods for infants if fresh milk is obtainable. In reference to the artificial foods, the two quotations following represent the opinions of independent observers, and may be accepted as indicative of the general conclusions of all authorities:

'There are two diseases—rickets and scurvy—which have so frequently followed their prolonged use, that there can be no escaping the conclusion that they were the active cause. This is the unanimous verdict of all physicians whose experience entitles them to speak with authority upon the subject of infant-feeding' (Emmett Holt).

'Clinical observation has proved, however, that a prolonged exclusive diet of condensed milk often results in the development of such nutritional disorders as anæmia, rickets, scurvy, and athrepsia. Moreover, the infant, while apparently healthy, lacks vital resistance, and easily succumbs to the various infectious diseases which he may contract' (Judson and Gittings).

With the constitution of these proprietary foods before us, and the practically unanimous verdict upon them from observers in all countries, it would seem unnecessary to say more.

But the fact remains that thousands of infants die each year in this country, and an inestimable number suffer from disease and deformity, which leave their traces throughout life, as a result of artificial feeding. This matter is therefore of urgent importance.

The great factor in the use of proprietary foods and condensed milk is their fatal facility for use. However simple the modification of cow's milk may be, it implies the daily supply of milk and many tiresome precautions. On the other hand, the mother is assured by label and advertisement that this or that preparation has only to be added to water in a certain proportion to provide a perfect food for the infant.

The 'digestibility' of some of these preparations is not to be denied. Young infants often take them very much better than they do the inaccurate modifications of cow's milk. For this there are two reasons. In the dried foods and condensed milks the processes of preparation cause the curd of the caseinogen to be precipitated in a finer state than that of ordinary cow's milk. But the great cause of their digestibility is the extremely small amount of food that they contain.

The soluble carbohydrates are usually in great excess, but the materials essential for physiological nutrition are invariably deficient. The infant's incapability of digesting the unmodified proteid of cow's milk renders it necessary to adopt measures by which it receives all the essential food elements in their proper character and proportion. The infant-food manufacturer eludes the problem by providing a 'food' which taxes the digestion of the infant but little, for the reason that the amount of material requiring to be digested is so small. The danger of these

foods is the greater because the disorders arising from defective feeding, while apparent to the skilled observer, for a long time escape the eye of the mother or attendant responsible for the care of the young infant.

So long as the infant is 'satisfied,' little attention is paid to the general absence of the signs of health. The onset of disease is extremely insidious, and the anæmia, rickets, and scurvy, only slowly develop. Many of these infants never live for a period of time sufficient to allow of the development of specific disease. They are pallid, flabby, listless. Some slight intestinal derangement, arising from, perhaps, a dose of castor-oil or from an excess of indigestible food, occurs. Convulsions ensue; the fits increase in frequency and severity; the infant has no power of rallying, and the most persevering treatment fails to gain any response, so that in the space of twenty-four hours, or less, the infant is dead. Or, perhaps, it is attacked by bronchitis or by one of the specific infective diseases. Death ensues almost before the disease has had time to establish itself. This *want of resistance* is the index of improper feeding and imperfect nutrition.

CHAPTER VI

THE MILK-SUPPLY

DESPITE the great advances in sanitation throughout this country, it is an extraordinary fact that the general milk traffic is carried on by methods which are opposed to the first principles of cleanliness.

No product calls for greater precautions in regard to all the details of its handling than milk, and the present system is characterized by an almost complete absence of the measures absolutely necessary to insure a pure supply.

Conditions of the Milk-Supply.—In London it is possible to obtain pure, fresh milk, free from deleterious bacteria, and supplied under proper conditions—that is, in sealed bottles. But the milk at present thus supplied constitutes an almost negligible fraction of the total supply. The milk-supply of London is drawn from the surrounding country within a radius of about one hundred miles. Soon after the cows are milked, care is taken in some cases to cool the milk by the use of some form of apparatus. This cooling undoubtedly retards bacterial growth, but it is seldom carried out at all efficiently. Ice or refrigerating machinery is almost never used, and the temperature of the cooled milk depends upon the temperature of the water supplied at the farm. Thus, the milk seldom falls to a temperature as low as 50° F., except possibly in cold weather, while the precautions taken to keep the milk cool after this preliminary treatment are conspicuous by

their absence. When we come to examine in detail the process of the production, collection, and delivery of cow's milk, the conditions are found to be so hopelessly bad, the ignorance and carelessness displayed on all sides are so extensive, that no serious improvement is possible without a complete revolution of the whole system.

Insanitation.—The state of affairs at the average farm where milch cows are kept is exceptionally filthy. The cow-house is dirty; in the great majority of cases it is insanitary in the extreme. In respect of drainage and ventilation, the arrangements in most cases could scarcely be worse. Everything is pervaded with cow-dung, urine, dirty fodder, etc. The cows themselves are covered with filth, dried dung being its chief constituent. The floor on which they stand is covered with an oozing mass of excreta, and the effluvia baffles description. It need hardly be said that, under such conditions, the cows appear to be far from healthy; they seem, in general, to look ill and out of condition. It is scarcely matter for wonder that tuberculosis is rife, and that this is one of the scourges of farms.

The diet of the cows is characterized by the exclusion of wholesome food, and by the substitution for it of brewer's grains, oil-cake, and other products having a definitely prejudicial effect on the milk.

Contamination.—In the person of the milkers and in all the details of milking, no opportunity of contaminating the milk would seem to be lost. Cow-dung is a normal constituent of the milk as supplied. For a description of the practices resorted to, the reader is referred to an account published in the *British Medical Journal*:[1] 'Against one wall of the shed was banked up a great heap of manure, while on the opposite side all the cinders, old bones and general rubbish of the farm were accumulated. . . . I was horrified to see the filthy state of the milk as it

[1] 'The Milk-Supply of Large Towns,' March 28, 1903.

flowed out of his pail. It was discoloured with grit, hairs and manure. "Look at that," I said, pointing to a specially large bit of manure. I regretted my zeal, for he dipped his whole hand into the pail, and, as he brought it out, said: "Oh, that ain't nothing; that's only off the cow."'

The author, from his own observation, can confirm every statement in the account of this writer, and could supply many instances where the practices were even more filthy. Into all the devious methods by which milk is further contaminated during delivery and transit it is scarcely necessary to enter. It would seem as if they had been designed with a perverse ingenuity to secure the greatest degree of contamination in the shortest possible time.

In one of the most prominent thoroughfares in the West End of London is a milk-shop, belonging to a well-known dairy company. Standing on the counter, within a few yards of continuous and dense traffic, is a wide, open bowl. Inside this bowl is the liquid which must be termed by courtesy 'milk.' On the outside of this bowl, facing the street, is emblazoned in gold letters the inscription 'Pure Milk.' When such a travesty as this can be perpetrated by a company, doubtless anxious in regard to its reputation, without, apparently, provoking the smallest hostility on the part of the public, it is scarcely necessary to inquire further into the methods which they employ.

The sort of care exercised may be illustrated by the following facts in relation to a large company which makes a great point, in its advertisements, of medical and veterinary certificates.

In a large provincial town, a milk company took systematic precautions to protect the milk passing through its hand. One of the farmers supplying them was found to have a case of infectious disease on the farm. They immediately ceased to receive any milk from this farm, while compensating the farmer by paying for the milk

as if it had been received by them. It was afterwards discovered that the case of infection had proved to be by no means unprofitable to the farmer. The whole of the milk rejected, but paid for, by the provincial company was bought for a second time from the farmer by the London firm, who sold it retail to its London customers.

The results of the present methods are that the milk supplied swarms with bacteria and contains every kind of filth; or, where the number of bacteria is comparatively small, the milk contains various injurious substances which have been added in order to retard its decomposition.

Eastes[1] examined 186 samples of milk obtained from all parts of the kingdom—from medical officers of health, public institutions, and private sources. Pus or muco-pus was found in 134 cases; blood was present in 24 samples, and streptococci were present in 106 cases. According to the results of the examination, 80 per cent. of the milks were unfit for human consumption.

Infectious Diseases.—The part played by milk in regard to infectious disease is demonstrated by the facts collected by Kober.[2] In 1900 he collected the records of 330 outbreaks due to the agency of milk. There were 195 outbreaks of typhoid fever, 99 of scarlatina, and 36 of diphtheria. In the typhoid epidemics the infection was traced to the dairy in 148 instances. In 67 the well-water was infected; in 7 the cows probably waded in infected water; in 24 cases the employees acted as nurses, and in 10 they continued at work although themselves suffering from the disease. In 1 case the milk-pans were washed with cloths used about patients; in 2 cases the dairy employees were connected with the night-soil service; and in 1 case the milk had been kept in a closet in the sick-room.

Of the 99 epidemics of scarlatina, the disease occurred at the farm or dairy in 68 cases. In 17 cases the employees

1 'The Pathology of Milk,' *British Medical Journal*, 1899, vol. ii.

2 *American Journal of the Medical Sciences*, May, 1901.

were affected, and in 10 cases they acted as nurses. In 6 cases persons connected with the dairy lodged in or visited infected houses; in 2 cases empty cans or bottles were brought from infected houses; in 3 cases the milk was stored in or near an infected room; and in 1 case the utensils were wiped with a contaminated cloth.

Of the 36 epidemics of diphtheria, in 13 cases the disease occurred at the farm or dairy. In 3 cases the employees themselves were suffering: in 12 cases the disease was apparently traced to a cow who suffered from disease of the udder.

Bacterial Development.—In regard to non-specific organisms, the enormous development of bacteria is illustrated by the tables of Miquel and Backhaus. Holt quotes two striking instances illustrating the importance of proper precautions. The observations were made at the laboratory of the New York Health Department.

	Bacteria.
A sample of milk taken under good conditions contained, immediately after milking, in each drop	300
It was cooled to 45° F., and kept at this temperature.	
After twenty-four hours it contained in each drop	200
After forty-eight hours „ „ „	900
After seventy-two hours „ „ „	150,000
Another sample, taken in a dirty barn, cooled and kept at 52° F., contained, at first, in each drop	2,000
After twenty-four hours it contained in each drop	6,000
After forty-eight hours „ „ „	245,000
After seventy-two hours „ „ „	16,500,000

The factors of bacterial development, in regard to the purity of milk, demands special consideration, and the chief facts in regard to this are discussed in Chapter VIII.

Medical Commissions.—The observations of various observers in different countries demonstrate the fact that the milk supplied is, in general, quite unfit for use. It becomes, therefore, an absolute necessity to lay down the principles and rules which must govern the handling of milk. In America, great strides have been made in the

solution of this problem. Medical Commissions have been established whose business it is to supervise the milk traffic, and to append their certificate to milk produced and handled in a manner in accordance with their requirements.

Whether the process of certification in this country would be equally successful is, under the present circumstances, open to much doubt. The whole value of a certificate depends upon the authority of those signing it. While one company might gain a fully-deserved certificate from an independent authority, it would be open to any dairy company to obtain a certificate of some sort or another, which, however valueless from a scientific point of view, might, at any rate, do much to mislead the public.

Further, it would be easy for a milk company to obtain a specimen of milk under the strictest precautions, and to submit this specimen so obtained for examination. The resulting certificate would, of course, only be applicable to the actual specimen submitted; but, having regard to the ignorance of the public, and the general attitude of the milk companies, it is by no means improbable that such a certificate would be made use of in reference to milk of a totally different character.

Whatever methods may prove to be the most practicable, it is a matter of imperative importance that the disgraceful conditions of the general milk-supply of this country should be ended. No trivial improvements or alterations of a minor character can effect this. Radical changes are required in everything concerned with the handling of the milk from the time it leaves the cow to the time it reaches the consumer.

The following circular, which is issued by the New York Commission, explains itself and presents a concise summary of the precautions necessary to be adopted in the regulation of the milk traffic.

Circular of Information concerning the Requirements of the Milk Commission of the Medical Society of the County of New York for 'Certified Milk.'

The Commission appointed by the Medical Society of the County of New York to aid in improving the milk-supply of New York City invites the co-operation of the milk-dealers and farmers in attaining that end. The sale of pure milk is of advantage to those furnishing it, as well as to those who use it. The Commission has undertaken to assist both consumer and producer by fixing a standard of cleanliness and of quality to which it can certify, and by giving information concerning the measures needful for obtaining that degree of purity.

The most practicable standard for the estimation of cleanliness in the handling and care of milk is its relative freedom from bacteria. The Commission has tentatively fixed upon a maximum of 30,000 germs of all kinds per cubic centimetre of milk, which must not be exceeded in order to obtain the endorsement of the Commission. This standard must be attained solely by measures directed towards scrupulous cleanliness, proper cooling, and prompt delivery. The milk certified by the Commission must contain not less than 4 per cent. of butter fat on the average, and have all other characteristics of pure, wholesome milk.

In order that dealers who incur the expense and take the precautions necessary to furnish a truly clean and wholesome milk may have some suitable means of bringing these facts before the public, the Commission offers them the right to use caps on their milk-jars stamped with the words 'Certified by the Commission of the Medical Society of the County of New York.' The dealers are given the right to use these certificates when their milk is obtained under the conditions required by the Commission and conforming to its standards.

The required conditions are as follows:

1. The Barnyard.—The barnyard should be free from manure and well drained, so that it may not harbour stagnant water. The manure which collects each day should not be piled close to the barn, but should be taken several hundred feet away. If these rules are observed, not only will the barnyard be free from objectionable smell, which is always an injury to the milk, but the number of flies will be considerably diminished. These flies in themselves are an element of danger, for they are fond of both filth and milk, and are liable to get into the milk after having soiled their bodies and legs in recently visited filth, thus carrying it into the milk. Flies also irritate cows, and by making them nervous reduce the amount of their milk.

2. THE STABLE.—In the stable the principles of cleanliness must be strictly observed. The room in which the cows are milked should have no storage loft above it; where this is not feasible, the floor of the loft should be tight, to prevent the sifting of dust into the stable beneath. The stable should be well ventilated, lighted, and drained, and should have light floors, perferably of cement. They should be whitewashed inside at least twice a year, and the air should always be fresh and without bad odour. A sufficient number of lanterns should be provided to enable the necessary work to be properly done during dark hours. There should be an adequate water-supply and the necessary wash-basins, soap, and towels. The manure should be removed from the stalls twice daily, except when the cows are outside in the fields the entire time between the morning and afternoon milkings. The manure gutter must be kept in a sanitary condition, and all sweeping and cleaning must be finished at least twenty minutes before milking, so that at that time the air may be free from dust.

3. WATER-SUPPLY.—The whole premises used for dairy purposes, as well as the barn, must have a supply of water absolutely free from any danger of pollution with animal matter, and sufficiently abundant for all purposes and easy of access.

4. THE COWS.—The cows should be examined at least twice a year by a skilled veterinarian. Any animal suspected of being in bad health must be promptly removed from the herd, and her milk rejected. Never add an animal to the herd until it has been tested with tuberculin, and it is certain that it is free from disease. Do not allow the cows to be excited by hard driving, abuse, loud talking, or any unnecessary disturbance. Do not allow any strongly-flavoured food, like garlic, which will affect the flavour of the milk, to be eaten by the cows.

Groom the entire body of the cow daily. Before each milking wipe the udder with a clean damp cloth, and when necessary wash it with soap and clean water, and wipe it dry with a clean towel. Never leave the udder wet, and be sure the water and towel used are clean. If the hair in the region of the udder is long and not easily kept clean, it should be clipped. The cows must not be allowed to lie down after being cleaned for milking until the milking is finished. A chain or rope must be stretched under the neck to prevent this.

All milk from cows sixty days before and ten days after calving must be rejected.

5. THE MILKERS.—The milker should be personally clean. He should neither have nor come in contact with any contagious disease while employed in milking or handling milk. In case of any illness in the person or family of any employee in the dairy, such employee

must absent himself from the dairy until a physician certifies that it is safe for him to return.

Before milking the hands should be thoroughly washed in warm water with soap and a nail-brush, and well dried with a clean towel. On no account should the hands be wet during the milking.

The milking should be done regularly at the same hour morning and evening, and in a quiet, thorough manner. Light-coloured washable outer garments should be worn during milking. They should be clean and dry, and when not in use for this purpose should be kept in a clean place protected from dust. Milking-stools must be kept clean. Iron stools, painted white, are recommended.

6. Helpers other than Milkers.—All persons engaged in the stable and dairy should be reliable and intelligent. Children under twelve years should not be allowed in the stable during milking, since in their ignorance they may do harm, and from their liability to contagious diseases they are more apt than older persons to transmit them through the milk.

7. Small Animals.—Cats and dogs must be excluded from the stables during the time of milking.

8. The Milk.—The first few streams from each teat should be discarded, in order to free the milk-ducts from milk that has remained in them for some time, and in which bacteria are sure to have multiplied greatly. If in any milking a part of the milk is bloody or stringy, or unnatural in appearance, the whole quantity of milk yielded by that animal must be rejected. If any accident occurs by which the milk in a pail becomes dirty, do not try to remove the dirt by straining, but reject all the milk and cleanse the pail. The milk-pails used should have an opening not exceeding 8 inches in diameter.

Remove the milk of each cow from the stable immediately after it is obtained to a clean room, and strain it through a sterilized strainer.

The rapid cooling of milk is a matter of great importance. The milk should be cooled to 45° within one hour. Aeration of pure milk beyond that obtained in milking is unnecessary.

All dairy utensils, including bottles, must be thoroughly cleansed and sterilized. This can be done by first thoroughly rinsing in warm water, then washing with a brush and soap or other alkaline cleansing material and hot water, and thoroughly rinsing. After this cleansing they should be sterilized with boiling water or steam, and then kept inverted in a place free from dust.

9. The Dairy.—The room or rooms where the bottles, milk-pails, strainers, and other utensils, are cleaned and sterilized should be separated somewhat from the house, or, when this is impossible, have

at least a separate entrance, and be used only for dairy purposes, so as to lessen the danger of transmitting through the milk contagious diseases which may occur in the home.

Bottles after filling must be closed with sterilized discs and capped, so as to keep all dirt and dust from the inner surface of the neck and mouth of the bottle.

10. EXAMINATION OF THE MILK AND DAIRY INSPECTION.—In order that the dealers and the Commission may be kept informed of the character of the milk, specimens taken at random from the day's supply must be sent weekly to the Research Laboratory of the Health Department, where examinations will be made by experts for the Commission, the Health Department having given the use of its laboratories for this purpose.

The Commission reserves to itself the right to make inspections of certified farms at any time, and to take specimens of milk for examination. It also reserves the right to change its standards in any reasonable manner upon due notice being given to the dealers.

Milk Commissions have been established in other cities, such as Baltimore, Boston, Buffalo, and Philadelphia. The regulations of the Philadelphia Commission are, in general, of the same character as those above quoted, but in many details they are more explicit and demand fuller precautions. Some of the most important provisions of this Commission are here printed in italics:

'The Commission shall select a bacteriologist, a chemist, and a veterinary inspector. The bacteriologist shall procure a specimen of milk from the dairy, or *preferably from delivery waggons*, at intervals to be arranged between the Commission and the dairy, but in no case at a longer interval than one month. The exact time of the procuring shall be without previous notice to the dairy. He shall test this milk for the *number* and *nature* of bacteria present in it, to the extent which the needs of safe milk demand. He shall also make a microscopic examination of the milk for pus cells. Milk free from pus and injurious germs, and *not having more than* 10,000 *germs of any kind or kinds to the cubic centimetre*, shall be considered to be up to the required standard of purity.

'The chemist shall in a similar manner procure and examine the milk for the *percentage of proteids, fat, sugar, mineral matter, and water, present*. He shall also test its chemical reaction and specific gravity, and shall examine it for the presence of foreign colouring or other

matters or chemicals added as preservatives. Standard milk shall range from 1029 to 1034 specific gravity, be neutral or very faintly acid in reaction, contain not less than from 3·5 to 4·5 per cent. proteids, from 4 to 5 per cent. sugar, and not less than from 3·5 to 4·5 per cent. fat, and shall be *free from all foreign contaminating matter and from all addition of chemical substances or colouring matters.*

'Richness of cream in fat shall be specified, and shall vary not more than 1 per cent. above or below the figures named in selling. Neither milk nor cream shall have been subjected to heat before the examination has been made, nor at any time unless so announced to the consumer.

'The veterinary inspector shall, at intervals equal to those of the bacteriologist and chemist, and without previous warning to the dairy, *inspect the cleanliness of the dairy in general*, the care and cleanliness observed in milking, the care of the various utensils employed, *the nature and quality of the food used*, and all other matters of a hygienic nature bearing upon the health of the cows and the cleanliness of the milk, including also, as far as possible, an inquiry into the health of the employees on their farms. He shall also see that the cows are free from tuberculosis and other disease.

'. . . Any dairy, the milk of which shall be found by the examiners to be up to the standard of the Commission, shall receive a certificate from the Commission. . . .

'The dealers to whom certificates have been issued shall furnish milk to their customers *in glass bottles hermetically sealed* in a manner satisfactory to the Commission. In addition to the sealing, and as a guarantee to the consumer that the examination has been regularly conducted, there shall be pasted over the mouth of the jar, or handed to the customer with every jar, according to the discretion of the Commission, a certificate. . . .'

These two specifications, taken together, show what is being done in America and what ought to be done in this country. It will be noted that the New York Commission has 'tentatively' fixed on a standard of 30,000 bacteria per cubic centimetre as the maximum content. This, in the author's opinion, is too high. No doubt milk with so many bacteria may be, in certain cases, comparatively harmless, but with proper precautions milk should not contain this number of micro-organisms.

Such a number points to contamination resulting from inefficient precautions, and milk of this character should not be allowed a certificate. Yet the demand for a bacteriological standard is a great advance, and there is evidence in the circular quoted indicating that, in all probability, the high content at present allowed is in the nature of a concession to the farmer, and that these regulations will soon be made more stringent.

In this respect, the regulations of the Philadelphia Commission are in advance of those of New York. In regard to the composition of the milk, the regulation regarding the chemical examination, to determine the presence of the constituents of milk in their proper percentage, is a valuable one ; while the number of bacteria per cubic centimetre must not exceed 10,000, and this figure is much fairer to the consumer without pressing unduly upon the farmer. It will also be noticed that the microscopical examinations of the milk for pus cells is a valuable provision. We may therefore regard the regulation of the Philadelphia Commission as the model for other cities and other countries. Nothing but organization on the part of those concerned with the production and sale of milk, and on the part of the medical profession, in this country, is required to insure that the general milk-supply should be of a character answering to these requirements.

In reference to the question of cost, it must be said that the present retail price of milk may need to be somewhat increased. But to take this as the standard is unreasonable. The absolute neglect of all adequate precautions may enable the dairyman to supply 'milk' at twopence per pint, but the milk at present commonly supplied at this rate ought not to be supplied at all except with the caution that it is definitely contaminated. On the other hand, a comparatively slight increase in the retail rate per pint would mean a very great increase in

9

the gross receipts. Indeed, when worked on a large scale, the increased cost could not be serious, while, when worked on a small scale, the retail cost must necessarily be much higher in proportion. Precautions of the character indicated entail systematic organization, the application of which costs practically as much for 100 gallons of milk as it would for 1,000 gallons, and hence experiments on a small scale must necessarily be misleading in regard to the cost of production. It is impossible, however, to dismiss the question of cost as if it were of small importance. The milk-supply is one of national moment, and in reference to the great mass of the community a serious increase in the price of milk would be attended with unfortunate consequences. But the whole matter is rather one of proper organization and control than of real or permanent increase in cost.

In this matter many interests and many branches of knowledge are involved. It needs a combination of knowledge to determine the practical solution of the problem. The man of science and the man of the cow-house have both to deal with facts, but the knowledge of each is more or less limited to his environment. A combination of the theoretical and practical is necessary in order to arrive at the precise methods to be adopted. What can be done in numerous parts of America ought not to be impossible in this country. It is urgently necessary that some method should be evolved conformable to scientific requirements, satisfying the just demands of the milk-dealer, and meeting the needs of the general community.

CHAPTER VII

THE HEATING OF MILK AND THE RESULTING CHANGES

The dangers attendant upon contaminated milk have been discussed, and the instances quoted form but a fragment of the evidence that could be brought forward from all sides to demonstrate the part played by infected milk in the causation of specific infectious diseases and in the epidemic diarrhœa which carries off such a large number of infants each year.

The Boiling of Milk.—In consequence of this frequent contamination, various processes of heating milk have been introduced in order to destroy the germs of infection and thus protect infants and others from their effects. These methods have been warmly advocated by many writers, and the boiling or sterilization of milk has almost come to be regarded as a classic practice, typical of sanitary advance and medical progress. Cheadle has been one of the most prominent exponents of this view, demanding that, practically, in all cases the milk for infants' use should be boiled, and that the water used for dilution should also be boiled. 'In the first place, always have the milk boiled. . . . This is the first grand rule I would lay down, and it should be an invariable rule.'[1]

At the outset it must be said that, whatever be the excuse of expediency, the whole argument would appear

[1] 'Artificial Feeding and Food Disorders of Infants,' p. 64 ; 1902.

to be unsound and inconsistent with the principles of scientific procedure. To supply an infant with contaminated milk is certainly far from advisable, but milk containing pathogenic bacteria is contaminated whether heated or unheated.

The *prevention* of contamination is the prime necessity. Methods of counteracting the effects of contamination, so far from being regarded as sanitary advances, must be regarded as temporary expedients, possibly advisable under certain circumstances to avoid worse ills, but necessarily carrying with them the gravest reflection upon a system under which such procedures become advisable.

It is a remarkable fact that the profession which in this country has so enthusiastically embraced the principles of antiseptic and aseptic surgery should be content, for the most part, to advise the boiling of milk in order to counteract contamination, rather than deal with the essential factor—the original contamination.[1]

As the use of boiled or sterilized milk has become more general, the results have been far from what was expected, and the injurious effects are being frequently demonstrated. It is therefore important that the changes produced by the heating of milk should be understood.

Owing to the confusion of terminology that at present exists among writers on the subject, it is necessary to specify as definitely as possible what is meant by the terms 'sterilization,' 'pasteurization,' etc. Sterilization, for instance, is not effected by boiling for thirty minutes, and this term is frequently misapplied.

Effects of Heat on Milk.—Rotch has summarized some of the facts in relation to the action of heat on milk which are of especial importance in reference to the preparation of milk mixtures:

[1] Dr. Clement Dukes, of Rugby, has been a prominent advocate of the use of *unboiled* milk (*vide* letters in the *Lancet*, 1901 and 1902).

1. Most pathogenic organisms are destroyed at from 140° F. to 147° F. (from 60° C. to 63·9° C.).

2. Certain spores are not destroyed by a single pasteurization.

3. All spores are destroyed at a heat of 248° F. (120° C.).

4. All micro-organisms are destroyed at 154·4° F. (68° C.).

5. The tubercle bacillus has lived in a heat of 149° F. (65° C.) with one hour's exposure.

6. Lactalbumin, the chief constituent of the whey proteids, coagulates at 161·6° F. (72° C.).

7. The rennin enzyme is destroyed at 140° F. (60° C.).

Pasteurization.—On the degree of heat and the time of exposure involved in the term *pasteurization* there appears to be no definite agreement. Holt requires the temperature to be raised to 167° F. (75° C.), and so maintained for twenty minutes. Freeman names 155° F. (68·3° C.) as the temperature, and thirty minutes as the time of exposure. Leeds names 157° F. (69·4° C.) as the temperature.

The present author, when ordering pasteurization to be carried out, requires the laboratory to heat the milk to 150° F. (65·6° C.) for fifteen minutes. *Pasteurization* is, therefore, a somewhat vague term, not definitely connoting either precise length of exposure or precise temperature. The maximum temperature of *pasteurization* must be regarded as 167° F.; and this appears too high, since lactalbumin begins to coagulate at 161·6° F. The minimum may be regarded as 140° F.

Sternberg's table gives the exposure and temperature at which some of the chief micro-organisms succumb:[1]

[1] Quoted from Judson and Gittings, *op. cit.*

TEMPERATURE AND EXPOSURE NECESSARY TO DESTROY CERTAIN BACTERIA.

	Temperature.	Exposure.
Bacillus diphtheriæ - - -	58° C. (136° F.)	Ten minutes.
„ *typhosus* - - -	56° C. (133° F.)	„
Pneumococcus - - - -	52° C. (125° F.)	„
Bacillus coli communis - -	60° C. (140° F.)	„
„ *acidi lactici* - - -	56° C. (133° F.)	„
Staphylococcus pyogenes aureus -	58° C. (136° F.)	„
„ „ *albus* -	62° C. (144° F.)	„

Sterilization.—Sterilization of the milk implies that the length of exposure and the degree of heat must be such that all organisms and all spores are completely destroyed. If this is to be effected at one exposure, the heat must be extreme, and above the boiling-point of milk (101° C.). Miquel's figures for the destruction of all germs are: One hour at 105° C. (221° F.), half an hour at 108° C. (226·4° F.), fifteen minutes at 110° C. (230° F.).

Another method of sterilization is by heating to 100° C. (212° F.) for thirty minutes, and repeating this on the two following days, thus allowing the uninjured spores to develop into organisms, and be destroyed at the second or third heating.

Boiling.—Boiling implies the raising of milk to the temperature of 101° C. If complete sterilization is desired, this must be maintained for a long time—much longer than the time usually specified.

If this is not required, but only that the pathogenic organisms should be destroyed, then there is no need to raise the temperature above 150° F., when the milk is to be consumed within twenty-four hours.

The exposure of milk to heat is attended with various alterations in the character of the milk, and as these are of the first importance in reference to infant feeding, the character of these reactions must be recognised. Moreover, no amount of pasteurization or sterilization can convert an unclean milk into a clean one. These processes have no action on the *toxins* already formed in milk by

the action of bacteria. Boiling the milk when received in the house may kill the micro-organisms, but it cannot remove these poisons.

Marfan has reported an epidemic of acute gastro-enteritis occurring in children fed on sterilized milk. Jemma fed young rabbits on sterilized milk containing dead tubercle bacilli. These rabbits died within from fifteen to twenty days of cachexia, or, at a later period, of marasmus. Post-mortem examinations were made, but only enteritis and fatty degeneration of the liver were found. The author has seen many cases of gastric and intestinal disturbance arising from the toxins present in pasteurized and sterilized milk. Sterilization, then, to be effective must be carried out when the milk is quite fresh, and long before it reaches the consumer.

Objections to Sterilization. — But the most serious objection to sterilization is that it irretrievably injures the food of the infant, definitely destroying vital elements essential to nutrition. Anæmia, scorbutus, and other disorders, frequently owe their origin to the destruction of these elements. The observations of many authorities, and the facts related by so many physicians and chemists in different countries, must serve to demonstrate, beyond any doubt, the vital importance of adhering to natural conditions.

At high temperatures the calcium salts, which are normally soluble, enter into insoluble combinations. Unheated milk probably contains ferment-like bodies which are of value to the organism. Babcock and Russell found that milk when obtained in a sterile condition undergoes self-digestion, owing to the presence of a ferment which is destroyed by heat. Douglass[1] has observed that the vital property of fresh milk is destroyed at a high temperature.

The chief physical and chemical changes occurring in milk as the result of sterilization, according to various

[1] *Glasgow Medical Journal*, vol. iii., 1900.

authorities, have been tabulated by Judson and Gittings.[1] Lecithin and nuclein are decomposed, organic phosphorus is diminished, while the inorganic phosphorus is increased. The phosphates become insoluble, and precipitation of the calcium and magnesium salts occurs. Normal lactic acid fermentation is inhibited. The fat emulsion is injured or destroyed. The lactalbumin is coagulated, and caseinogen is only partially or not at all coagulated by rennin, this latter change being related to the precipitation of the calcium salts. Digestion of the caseinogen is delayed. After prolonged sterilization, albuminoid toxins may be produced.

Richmond[2] states that at about 80° C. (176° F.) certain organized principles, the nature of which is not fully known, undergo a change. The presence of these principles in an unchanged form is demonstrated by certain reactions. They cause an evolution of gas from peroxide of hydrogen in the cold, and give a blue colour with para-phenylene-diamine and hydrogen peroxide.

J. E. Saul[3] has published an important observation in relation to the alterations caused by heat. On treating milk with a solution of orthomethylaminophenol sulphate $[(OH).C_6H_4.NHMe]_2,H_2SO_4$, and then adding hydrogen peroxide solution, a very vivid, deep-red colour is produced. Milk that has been previously boiled and cooled remains uncoloured, a faint pink only developing on standing. The red colour is so strong and pronounced that so little as 1 per cent. of raw milk, if added to heated milk, may be detected with ease. The test may be applied as follows: To 9 or 10 c.c. of the milk add 1 c.c. of a recently prepared 1 per cent. aqueous solution of orthomethylaminophenol sulphate, and then add one drop of commercial hydrogen peroxide solution. The red colour develops within thirty

[1] *Op. cit.*, p. 230. [2] *Op. cit.*, p. 145.

[3] 'Note on the Detection of Raw Milk and Formaldehyde' (*British Medical Journal*, March 21, 1903).

seconds if there is any raw milk present in the sample. Excess of hydrogen peroxide should not be added, as it tends to weaken and bleach the colour. Dilute acids do not affect, caustic alkali destroys, the colour. The presence in the milk of boric acid, formaldehyde, or sodium bicarbonate, does not interfere with the reaction. If the milk is sour, the acidity should be neutralized before the test is applied. Saul has also determined the temperature at which these principles are destroyed. If milk is kept at 75° C. (167° F.) for thirty minutes, it fails to give the reaction; milk kept at 70° C. (158° F.) for an hour still reacts to the test. He concludes that there is present in milk an oxidizing enzyme destructible by heat.

Whatever may be the chemical explanation, the fact that sterilized milk is responsible for the production of scurvy and other diseases is a well-established fact.

Carstens and Von Starck have both found that the systematic use of sterilized milk leads to grave disturbances of nutrition, resulting in the development of severe anæmia, rickets and scurvy. Eighty-four out of 300 medical practitioners in Schleswig-Holstein reported the occurrence of rickets, anæmia, errors of development, and other disorders, arising from the use of sterilized milk. Numerous other observers[1] have confirmed these statements. The American Pediatric Society's investigations in regard to the incidence of infantile scurvy showed that 107 cases were due to sterilized milk.[2]

Holt points out that even 'pasteurization' at 167° F. for thirty minutes may result in scurvy. He has seen at least three such cases. In view of Saul's experiments, this clinical observation is especially interesting.

The above facts are sufficient to show that the heating of milk is attended with the greatest danger to nutrition, and that all our efforts should be in the direction of obtaining a pure, clean, and *fresh* milk.

[1] *Vide* Judson and Gittings, *op. cit.*   [2] *Vide* Chapter XVI.

As systematic practices, boiling, sterilization, and pasteurization must all be condemned. When heating appears to be necessary, the temperature should not exceed 150° F. For purely temporary purposes, as, for instance, where the infant is on board ship, and under other exceptional circumstances, pasteurization for a limited period may be advisable. In the case of milk modification, the great value of the divided proteids renders the heating of part of the mixture (the whey) to 140° F. necessary, in order to kill the rennin enzyme. The whey must therefore be heated, but for not longer than three minutes, nor at a higher temperature than 145° F.; the rest of the mixture, the fat-free milk, etc., should not be heated at all.

CHAPTER VIII

THE BACTERIOLOGY OF MILK

The Bacteriological Standard for Milk.—Conn has pointed out certain facts, in relation to the bacteriological examination of milk, which must be appreciated before we form conclusions drawn from bacteriological analysis. Whereas a sample of water containing a few thousand bacteria per cubic centimetre must be immediately regarded as suspicious, it is certain that a milk containing the same or a greater number of bacteria may be perfectly wholesome. A comparison of the number of bacteria in water and in milk will show, in water, a few hundred per cubic centimetre, and, in milk, many thousands. Even when compared with sewage, from the standpoint of the *number* of bacteria, milk proves to be surprisingly bad. The milk supplied to our cities frequently contains a greater proportion of bacteria than the city's sewage. In the case of unusually bad samples of milk the number of bacteria is in excess of the number found in the worst sewage. On the other hand, the presence of a small number of bacteria does not necessarily prove that the milk is wholesome, for among the small number may be organisms specifically pathogenic—such, for instance, as the *Bacillus typhosus*.

The great number of bacteria so frequently found in milk is due to the fact that it forms one of the finest nutrient media for their growth and development, far superior in this respect to either water or sewage. And

it is clear that neither the presence nor the number of bacteria in milk can be regarded in at all the same light as in the case of water. Yet, despite these qualifications, the number of bacteria found in milk forms an accurate and reliable guide when properly interpreted.

The Bacteriological Testing of Milk.—With proper precautions in the dairy and in transit, it has been proved that the number of bacteria can be kept within a certain maximum, and thus it is possible to determine by the bacteriological count the character of the methods of procuring and handling the milk. In practice this has proved to be a most satisfactory method. On the one hand, it has pointed out the precautionary measures that are necessary; on the other, it has been a most valuable check, at once calling the attention of those concerned to any defect.

Milk stands out from all other foods by virtue of its liquid condition. It contains within itself all the materials necessary to maintain life and encourage development. Hence it is above all other foods the one most liable to, and most affected by, bacterial contamination. In order to insure the systematic delivery of pure milk to the consumer, the greatest precautions are necessary in regard to all the details from the cow to the house at which it is delivered. A natural milk absolutely sterile is a practical impossibility. In the mammary gland itself the milk is in all probability entirely free from micro-organisms, but in passing through the udder—which is by no means sterile—milk necessarily comes to contain micro-organisms. Even if this were not so, the obtaining of a sterile milk would be an advantage of a purely theoretical character. In the mouth of both infant and adult hosts of non-pathogenic organisms exist, so that the sterile food becomes the reverse immediately it is taken.

Bacteria in Stomach and Intestine.—The infant's stomach usually contains from 4,000 to 240,000 bacteria.

In infants nursed at the breast the number present in the stomach has been ascertained to be from 7,000 to 20,000.[1] The infant may be fed on absolutely sterile food without in any way diminishing the bacteria present in the stomach and intestine; indeed, it is probable that a sterile food must result in the increase of the bacteria present in the alimentary canal, and in alterations of their character. Eberle[2] examined bacteriologically the fresh fæces of an infant fed on sterilized food. In 1 milligramme he found 33,000,000 organisms.

In storing milk we are making a wide departure from nature, and it is consequently necessary to counteract the effects of the artificial condition by measures calculated to absolutely prevent the growth of bacteria and the production of bacterial toxins. At 40° F. the bacterial development is practically nil; the bacteria originally present in the milk still exist, but they cannot develop to any serious extent.

The secretion of the mammary gland of the cow was, of course, intended for the nourishment of its offspring, and thus the food was transferred directly from the mammary gland of the mother to the stomach of the calf. Hence no external *development* of bacteria could occur. In the course of a long evolution, altogether unique in its wide departure from the primitive natural state, the mammary gland of the cow has been so greatly diverted as to become the source of one of our primal food-supplies. Moreover, as civilization has advanced and large towns have been formed, the problem has become more and more complex. The food intended for immediate consumption has been placed at greater and greater distances from the consumer, so that the milk-supply of London is derived from the country around within a radius of 100 miles.

[1] Langermann, *Jahrbuch für Kinderheilkunde*, Bd. xxxv., 1893.

[2] 'Zählung der Bakterien im normalen Säuglingskot' (*Centralblatt für Bakteriologie und Parasitenkunde*, Bd. xix., 1896).

Bacteria present in Pure Milk.—From the considerations already mentioned, it may be said that a large number of the micro-organisms present in good fresh milk are quite harmless; and, indeed, there is much evidence to show that certain of these organisms are distinctly beneficial to the infant.

Milk collected and handled with the most complete precautions always contains numerous bacteria. The milk of the Chestnut Hill Farm of the Philadelphia Laboratory was examined for 354 days in the Pepper Laboratory of the University of Pennsylvania. These examinations showed an average of 2,550 bacteria per cubic centimetre. There were only twenty days when the average was over 10,000. The lowest average number of bacteria was 1,150 per cubic centimetre.

Were all milk as free as this, the infant fed on it must receive millions of bacteria into its stomach. This is sufficient to demonstrate the absolute harmlessness of bacteria normal to milk when present in moderate number, for if these micro-organisms really exerted any noxious influence, it must inevitably happen, both from their number and their constant presence, that the death of the infant could only be a question of time. At least, their influence on the infant must be neutral, while it would seem that they must possess some beneficial action. For it is almost inconceivable that the natural development of the perfect food for the offspring should be marred by organisms which are as certainly present as the proximate principles of which milk is composed. From a scientific point of view we must, then, regard bacteria as a normal element of human milk and of the milk of all animals.

Bacteria in Human Milk.—In forty-three out of forty-eight specimens of human milk examined by Cohn and Neumann micro-organisms were found. These included the *Staphylococcus pyogenes albus*, the *Staphylococcus pyogenes aureus*, and the *Streptococcus pyogenes*. Honiggmann found

human milk sterile in only four out of seventy-six cases. No observer has been able to report a series of cases of human milk proved to be sterile. Marfan states that we may conclude that the milk of healthy mothers obtained under aseptic precautions contains micro-organisms in nineteen cases out of twenty.[1] It is usually agreed, however, by observers that only the earlier portions of the milk contain micro-organisms in at all large amount, and that these organisms are found in the neighbourhood of the openings of the lactiferous ducts, and not in the mammary gland itself.

The organisms described are those usually found as constant inhabitants of the skin, and are necessarily unavoidable, especially under circumstances where traces of milk are always present. The demand for a *sterile* milk is one that is, therefore, altogether superficial. In nature, under the most favourable conditions, it does not exist. In the case of the cow, the possibilities of contamination are enormously increased by reason of the presence in the cow-house of excreta, and by the great difficulty of keeping the cow clean.

The Effects of Contamination.—But while bacteria are present in the milk as received directly by the infant, there are two factors which are *not* present—the further external contamination of the milk after it has left the mammary gland, and the formation of toxins as a result of bacterial development.

Backhaus[2] carried out a series of investigations which demonstrate the extreme importance of attention to every detail in connection with the handling of milk. It will be seen from the figures following that apparently slight variations of method were attended with wide alterations in the bacterial content :

[1] Judson and Gittings, *op. cit.*

[2] Quoted by Klimmer. 'Genügt unsere Milchkontrolle . . .' (*Jahrbuch für Kinderheilkunde*, July, 1901).

THE EFFECTS OF THE PRECISE METHODS OF THE COLLECTION OF MILK UPON ITS BACTERIAL CONTENT.

	Per Cubic Centimetre.
Dry milking	5,600 germs.
Wet milking	9,000 „
First milk	10,400 „
Last milk	Sterile
When the cow is cleaned	20,600 „
When the cow is not cleaned	170,000 „
Udder washed	2,200 „
Udder not washed	3,800 „
If the cow is milked in the open air	7,500 „
If the cow is milked in a clean stall	29,250 „
If the cow is milked in an unclean stall	69,000 „
Enamelled vessels	1,105 „
Tin vessels	1,690 „
Wooden vessels	279,000 „
Sterilized vessels	1,300 „
Washed vessels	28,600 „
Fresh milk	6,660 „
Milk passed through six vessels	97,600 „
Turf	40,000 „
Good straw	150,000 „
Dirty straw	200,000 „
Fresh water	322 „
Trough water	228,200 „
Milk supplied from a good dairy farm	25,000 „
Milk supplied to the Königsberg market	2,000,000 „

The Storing and Delivery of Milk.—The next point of importance is concerned with the procedures connected with the storage of milk and its delivery to the consumer. In this respect, the precise temperature at which the milk is kept is of the greatest moment. Conn observed that a specimen of milk containing 153,000 bacteria per cubic centimetre contained no less than 85,000,000 twenty-four hours later.[1]

Cnopf and Escherich illustrated this rapid development by the annexed table:

[1] Chapin, 'Infant Feeding,' 1903.

RATE OF DEVELOPMENT FROM A SINGLE GERM.

	Two Hours.	Three Hours.	Four Hours.	Five Hours.	Six Hours.
54° F. - -	4	6	8	26	435
97° F. - -	23	60	215	1,830	3,800

At the time of milking, the temperature of the milk is about 100° F., and as this temperature is extremely favourable for bacterial development, and the medium is the best possible, the rate of development is prodigious. This fact is clearly brought out by Miquel, who observed the development in three specimens of the same milk, the only difference being the temperature.

NUMBER OF BACTERIA IN MILK EXPOSED FOR FIFTEEN HOURS.

	Per Cubic Centimetre.
At 59° F. (15° C.) - - -	100,000 bacteria.
At 77° F. (25° C.) - - -	72,000,000 ,,
At 95° F. (35° C.) - - -	165,000,000 ,,

Chapin quotes instances showing the importance of the bacteriological test. On a certain day in February, 1902, the count at the farm was 17,000 per cubic centimetre; at the creamery it had risen to 450,000. This was found to be due to the fact that a small quantity of water used in washing the bottles at the creamery remained in the bottles. After this, all the bottles were sterilized by steam, and the bacterial count at once became low. In March the count suddenly rose from 4,750 per cubic centimetre to 41,000. This was found to have been caused by the laying of a new floor in the creamery.

Though micro-organisms occur in milk in consequence of the presence of bacteria in the outermost portion of the lactiferous ducts, the *contamination* of milk is most frequently due to external sources. Dust, fæces, hay, and fodder, are common sources of infection, while the milker may be the means of almost immeasurably adding to the contamination. If his hands are dirty, the contamination

10

is great; while, if any infectious disorder be present, all the milk procured by him may be spoilt. Dirt, hair, flies, etc., swept from the body of the cow, often by its tail, also are sources of infection.

Dairy Bacteria.—The varieties of dairy bacteria are very numerous, and the most complete description of these has been given by Conn,[1] who has succeeded in isolating over 200 species, differing more or less distinctly from one another. Many of these are, however, of theoretical rather than practical interest, and he regards the chief bacteria as belonging to three groups, all associated with lactic acid fermentation, though differing in other respects.

Richmond[2] classifies the micro-organisms according to the following scheme:

1. Micro-organisms acting on milk-sugar causing fermentation—(*a*) with the production of lactic acid; (*b*) with the production of butyric acid; (*c*) with the production of alcohol.

2. Micro-organisms acting on proteids—(*a*) curdling milk without acidity, and not dissolving the curd; (*b*) curdling milk without acidity, and afterwards dissolving the curd: (*c*) peptonizing the proteids without curdling the milk.

3. Micro-organisms producing colouring matter.

4. Micro-organisms having no direct action on the milk.

5. Micro-organisms which are pathogenic, giving rise to specific pathological conditions.

Lactic Acid Fermentation.—The most common change in milk is the well-known 'turning,' due to the fermentation of the lactose. This is caused by a large number of bacteria, and it is doubtful whether many of the species described can be regarded as distinct organisms. Hueppe's

[1] Twelfth Annual Report of Storr's Agricultural Experiment Station, 1899.

[2] 'Dairy Chemistry,' London, 1899.

Bacillus acidi lactici, Esten's *Bacterium acidi lactici*, Escherich's *Bacillus lactis aërogenes*, are all closely allied to this group. Indeed, Marfan considers that all of these organisms represent varieties of the *Bacillus coli communis*, which is normally present in enormous numbers in the intestine.

A great amount of evidence has been collected in various directions pointing very strongly to the probability that many organisms which have been isolated and described as distinct organisms are only variations of a single type, the variation being due to alteration in situation, food, temperature, disease, health, and many other conditions.

The change in milk effected by these bacteria is as follows: The milk first becomes acid, and of a sour or bitter taste. When sufficient lactic acid has been formed, the caseinogen is coagulated. Up to a certain point the growth of these bacteria under favourable conditions is very rapid, but at the end of this period their development is much slower.

Great variations are found in the period of time required for coagulation. Certain types of these organisms are greatly retarded when lactic acid is present to the extent of 1 per cent., while others do not appear to be materially affected. Coagulation does not usually occur until the amount of lactic acid present equals about 8 per cent. Hence, where those varieties which are markedly hindered by the presence of lactic acid are in the preponderance, coagulation is delayed for some days. In the others, not so retarded, coagulation may occur in twenty-four hours.

This class of organisms is extremely susceptible to heat, so that at comparatively low temperatures they are completely destroyed. The *Bacillus acidi lactici* is destroyed by an exposure for ten minutes to a temperature of 133° F. (56° C.), the *Bacillus coli communis* at a temperature of 140° F. (60° C.) for the same period.

Butyric Acid Fermentation.—In the case of butyric acid fermentation, the milk does not become acid. The caseinogen is precipitated to a much greater extent than is the case in lactic acid fermentation. As the development of the bacteria progresses, an exceedingly bitter taste and an unpleasant and characteristic odour are developed. Coincident with these later changes butyric acid is formed, and the casein is taken into solution. This digestion of casein is due to the proteolytic functions possessed by these organisms. They are much more resistant to heat than the class above described, and it is noteworthy that, in the presence of the lactic group, butyric acid fermentation is greatly retarded. This decomposition of milk is very uncommon in comparison with the lactic fermentation.

Alcoholic Fermentation.—Alcoholic fermentation does not occur to any marked extent in milk under normal circumstances. Lactose is not acted upon by the ordinary ferments, such as *Saccharomyces cerevisiæ.* The derivation of alcohol from lactose can be obtained by the ferment present in kephir grains; this, however, never occurs under ordinary circumstances.

Peptonizing Bacteria.—The peptonizing bacteria are a large, ill-defined group. They are universally distributed, and constitute a serious danger in the case of pasteurized or sterilized milk. The two most prominent types of this group are the *Bacillus subtilis* (the 'hay bacillus') and the *Bacillus mesentericus vulgatus.*

By means of these and similar micro-organisms the caseinogen is coagulated without the occurrence of acidity, and the casein is then peptonized and further transformed into all the products of albuminoid decomposition, such as leucin, tyrosin, urea, fatty acids, ammonia compounds, and nitrogen.

The action of these bacteria is prevented by the presence of lactic acid.

In contrast to the lactic acid group, these organisms are remarkably resistant to high temperature. Flügge[1] observed that these forms were not destroyed though exposed to a temperature of 100° C. (212° F.) for three-quarters of an hour. If milk is kept for several days, at a temperature exceeding 72° F. (22° C.), or, for a few hours, at a temperature above 79° F. (26° C.), these bacteria will develop much more luxuriantly than in unheated milk, since in unheated milk the excess of lactic acid bacteria hinders the development of the others.

Weber[2] has also called attention to this aspect of the subject. Lactose checks putrefaction in milk, since it favours the development of bacilli which are antagonistic to the development of the peptonizing bacteria. In raw milk this peculiarity of lactose is fully present. In milk which has been heated this property has been either impaired or destroyed. These facts in relation to the practice of infant feeding are of the first importance.

The products of the peptonizing bacteria are often extremely poisonous, and, as these organisms escape destruction at a temperature of 212° F., the danger incurred by their presence is serious. In infants, a very small amount of such substances may produce the most serious gastric and intestinal disorder.

Another class of organisms causes peptonization without curdling. Richmond has separated an organism of this kind from the Armenian preparation 'mazoum.'

A large group of bacteria, not directly pathogenic, are associated with alterations in milk resulting in the production of pigment. *Blue milk* is caused by the *Bacillus cyanogenus* (which is only active in the presence of acid), the *Bacillus cyaneo-fluorescens*, and the *Bacillus janthinus*.

[1] 'Die Aufgaben und Leistungen der Milchsterilisirung' (*Zeitschrift für Hygiene und Infections-Krankheiten*, Bd. xlvii., 1894).

[2] 'Die Bakterien der sogenannten sterilisirten Milch des Handels' (*Arbeiten aus dem Kaiserliche Gesundheitsamte*, Bd. xvii., 1900).

Red milk is due to the *Bacillus prodigiosus*, *Bacillus lactis erythrogenes*, *Spirillum rubrum*, *Micrococcus cinnabareus*, and the *Sarcina rosea*.

Various other changes in the physical characters of milk are caused by other organisms. Viscous milk is due to the action of the *Bacillus lactis viscosus*, the *Bacillus lactis pituitosi*, and several other varieties.

Pathogenic Bacteria.—The part played by pathogenic bacteria present in milk in the dissemination of diseases such as scarlatina, diphtheria, cholera infantum, and many other specific diseases, has already been referred to. In general it may be said that these infections arise from—(1) disease in the milkers or those concerned with the handling of the milk, or their families; (2) the infected water used with the object of cleansing the various utensils or for adulteration. In regard particularly to scarlatina and to epidemic enteritis, the source of infection has frequently been traced in the most complete manner to the milk-supply.

In reference to the tubercle bacillus, it must be admitted that the evidence of direct infection from bovine tuberculosis is not complete, though the balance of evidence appears to point in this direction. But however this may be, it is of small moment in reference to practical dairy management. For the milch cow should be demonstrably healthy, and in no properly managed dairy should milk be taken from a cow suffering from tuberculosis, either general or localized. The systematic testing by *tuberculin*, and the immediate exclusion of any cow giving the reaction, must be a rule never to be departed from.

In this brief summary of the bacteriology of milk, the author has endeavoured to point out the essential features of the bacteriological infection of milk. Exaggeration in these matters is much to be deplored, and that there has been an exaggeration of some aspects of the question can

scarcely be doubted. While certain bacteria are the source of the most virulent diseases, other bacteria play a part almost as powerful in the prevention of disease. The facts demonstrated by independent and authoritative observers in regard to the antagonism between the lactic acid and the peptonizing bacteria afford a striking instance of this aspect of the subject. The relationship between the hygienic bacteria and the digestion of the infant again illustrates the value of certain forms of micro-organisms.

The bacteriological analyses of human milk which have been quoted show how exceptional it must be for the human infant fed by its mother to receive a sterile milk. In reference to substitute feeding, we have to secure that the milk used shall be pure, and, as regards bacteria, as closely as possible approximating to its condition when received by the calf direct from the cow.

Given a healthy cow, the deleterious bacteria arise entirely from growth and development of the bacteria occurring during the storage of the milk at a temperature favouring this, and from contamination arising during the milking or at some later stage in the handling of the milk. All our endeavours should be exerted to preserve its pristine purity, and the technique here required is one demanding the most persistent vigilance.

CHAPTER IX

THE FUNCTIONS OF BACTERIA IN RELATION TO DIGESTION

Bacteria present in the Stomach.—At birth the contents of the stomach and intestine are sterile; within a few hours numerous forms of bacteria are found, and in a few days the whole alimentary tract contains myriads of organisms. Van Puteren[1] examined the stomach contents of forty healthy infants from four to seven days old, some being breast-fed, and others fed on cow's milk. The stomach contained about twenty times as many organisms in the case of those infants fed on cow's milk as those that were breast-fed. This variation is undoubtedly due to the contamination of cow's milk. In Van Puteren's figures the evidence of contamination in the case of the hand-fed is very distinct—the presence of the *Bacillus subtilis* and of the *Bacillus butyricus* almost certainly owing their origin to this source.

He found the *Bacillus lactis aërogenes* present in 37·6 per cent. of the breast-fed and in 45 per cent. of those bottle-fed; the *Bacillus subtilis* was present in 11·7 per cent. of the breast-fed and in 36·8 per cent. of the bottle-fed. In the breast-fed the *Oidium lactis* was found in 12·9 per cent., and in the others in 27·3 per cent. The *Staphylococcus pyogenes aureus* was present in 16·4 per cent. of the breast-

[1] 'Micro-Organisms in the Stomach and Intestine of the Infant.' *Vrach* (St. Petersburg), vol. ix.

fed and in 27·2 per cent. of the bottle-fed. The *Bacillus fluorescens liquefaciens* and the *Bacillus butyricus* were not found at all among the breast-fed, but the former bacillus was found in 24·3 per cent. of the bottle-fed, while in every case where the infant was fed upon cow's milk the *Bacillus butyricus* was present.

While many forms of bacteria present are the result of the external contamination of cow's milk, others are present in the stomach, whether the method of feeding is natural or otherwise. Of these latter, the lactic acid bacilli are the most important, since their functions are of great value to the infant, and it is noteworthy that the difference in regard to the *bacillus lactis aërogenes* between the breast- and bottle-fed infants is less than 10 per cent.

In reference to the number of bacteria present, Langermann[1] found that the stomach of the infant normally contained from 3,700 to 240,000 bacteria per cubic centimetre; that, even in the presence of free hydrochloric acid, they existed in numbers between 3,200 and 6,400 per cubic centimetre, while in cases of digestive derangement the number of bacteria may be enormous.

Bacteria present in the Intestine.—Escherich's researches afford the most complete illustration of the part played by bacteria. At birth the meconium is sterile, but infection by the mouth and rectum quickly occurs, and in a short time almost any form may be found, but chiefly such putrefying forms as the *Proteus vulgaris*.

When the infant is fed, and the refuse of milk together with the intestinal secretion replaces the meconium, a marked change is seen, and only two forms are commonly found—the *Bacillus lactis aërogenes* and Brieger's bacillus, the first in the upper, the second in the lower, parts of the intestine. When the infant comes to a mixed diet, numerous other forms appear. Escherich attributes the absence of the other forms during the milk diet to the

[1] *Jahrbuch für Kinderheilkunde*, Bd. xxxv., 1893.

association of this diet with the presence of the *Bacillus lactis aërogenes.* This bacillus is found in great numbers in the upper part of the intestine in milk-fed infants, and it converts a great part of the lactose into lactic acid, and thus prevents the development of other micro-organisms.

Biedert's observations[1] confirm these. The *Bacillus lactis aërogenes* splits up lactose into lactic acid, carbon dioxide and water, and thus fermentation of the chyme occurs. This organism is chiefly present in the upper part of the small intestine. It is responsible for the production of the acid reaction.

The *Bacillus coli communis* is the chief organism present in the lower intestine. It grows in the presence of alkaline or acid reactions, and is capable of fermenting lactose, with the production of lactic acid. It is also characterized by its function of splitting the neutral fats into fatty acids. Escherich, however, appears to doubt whether the lactic fermentation is normally accomplished by means of the *Bacillus coli communis.* Until the supply of lactose is practically exhausted, and the activity of the *Bacillus lactis aërogenes* is consequently inhibited, the *Bacillus coli communis* does not come into action. As soon, however, as this is accomplished, the latter acts on remnants of lactose and albumin and breaks up the fats.

In correspondence with the cessation of activity of the lactic acid bacilli and the development of activity by the colon bacillus towards the lower part of the intestine, the strong acid reaction declines, until, at the beginning of the colon, the reaction is alkaline. As long as the intestinal reaction is acid, the fermentative changes above described take place, but *putrefaction* does not usually occur till the acid reaction is either very weak or has been replaced by an alkaline reaction.

These facts demonstrate at once how complex and how mutually interdependent are the processes of digestion and

[1] *Kinderernährung im Säuglingsalter*, 1900.

absorption, especially in the young infant living exclusively on a milk diet. In the management of infant feeding and in the treatment of disorder, these factors have received but scant recognition.

Many methods practised in infant-feeding and in infantile disorders must be regarded, in the light of these facts, as altogether arbitrary and harmful. Such complex processes as these can only be regulated when the essential factors receive due recognition. They illustrate, for instance, the complete futility of the systematic use of intestinal antiseptics.

Pathological Action of Bacteria.—There is a great deal of evidence to show that under abnormal circumstances many of the bacteria usually inhabiting the intestinal tract may, by their irregular growth and development, exhibit virulent properties, causing serious disorder. Indeed, in the absence of specific infection, the *Bacillus coli communis* may be regarded as largely one of the prime causative agents of intestinal disorder, this having been led up to by improper diet, enabling the bacillus to flourish at the expense of its antagonist. There can, again, be little doubt that the severe intestinal decomposition set up in young infants from exposure to cold is due to the chilling of the intestine, which permits the perverted action of the colon bacillus. In other cases, though they seem to be rare in infancy, the *Bacillus lactis aërogenes* may become virulent.

In regard to this phase of the question, there is much that is as yet indefinite, owing to the difficulties inherent in estimating the degree of virulence of bacteria. But sufficient observations have been recorded to demonstrate that in many cases bacteria not generally pathogenic may become so under conditions favourable to this development.

Delépine,[1] in a paper read before the Epidemiological Society, observed that the bacteria suspected on good

[1] *British Medical Journal*, February 21, 1903.

grounds to be the cause of outbreaks of summer diarrhœa belonged chiefly to types which were the inhabitants of the alimentary canal. The virulence of these microbes was capable of considerable variation. The colon bacilli appeared to be most intimately connected with epidemic diarrhœa. He related the circumstances of an epidemic of diarrhœa at Victoria Park, Manchester, due to cow's milk. The outbreak was at the time attributed to the milk from a cow suffering from disease of the udder; but he came to the conclusion that the infection of the milk was more probably due to pollution with excreta of a specially virulent character.

Among the three varieties of bacilli of the colon group found in the milk, one (which had most of the characteristics of the *Bacillus enteritidis* of Gaertner) was pathogenic, a single loopful of pure culture on agar causing death in a guinea-pig within twenty-four to thirty hours. Fæcal contamination of milk frequently occurred. When some animals in the herd were affected with intestinal inflammation, virulent bacilli would exist in the excreta, and would gain access to the milk by contamination.

In addition to increase of virulence, excessive development of bacteria in point of number, or their presence in parts of the intestine where they are not normally present, may give rise to disorders of varying severity. For both the chyme and the chyle are highly putrefactive substances, being loaded with food for bacteria under the most favourable conditions of temperature and physical conditions for prolific bacterial development. The health and life of the infant are entirely dependent for the prevention of this bacterial putrefaction upon certain bacteria, whose function it is to stay the inroad or development of organisms inimical to the normal processes.

CHAPTER X

THE CHEMISTRY OF INFANTILE DIGESTION

THE processes of digestion and absorption in the infant present many important differences from those observed in the adult, and, as would naturally be expected, these differences are essentially connected with the exclusive diet. While there are many differences of opinion in regard to the ultimate chemical reactions occurring in digestion, the testimony of the most accurate observers is in general agreement in regard to the broad factors.

The Saliva.—The salivary and parotid glands are small and inactive at birth, and the secretion of ptyalin is not definitely established till about the sixth month, though in certain individuals traces of this may be found from birth. Jacobi[1] states that the diastatic ferment is present in the first month, but that the secretion is usually scanty in amount in very young or weak infants. Ptyalin may be found in the parotid gland at birth, and in the submaxillary and sublingual glands about the fourth week, but the saliva has practically no diastatic function until about the end of the first year. Various observers have shown that no constant amylolytic function is possessed by the saliva until about the fourth month.[2]

[1] Jacobi, 'Therapeutics of Infancy and Childhood,' second edition, 1898.

[2] *Vide* Monti, 'Kinderheilkunde in Einzeldarstellungen,' Vienna, 1899; Thomson, 'Guide to the Clinical Examination and Treatment

The chemical action of the saliva is probably in all cases a comparatively unimportant part of its functions, since this action is so brief owing to its neutralization in the stomach. Both in infancy and in adult life the most important function of the saliva appears to be that of moistening and lubricating the mucous membrane of the mouth, and its function is more valuable when mastication becomes necessary. The digestion of starch is carried out in the intestine by the pancreatic secretion. The question, therefore, of the date of the precise appearance of ptyalin is rather of theoretical than practical interest. Even when the amylolytic action is present, as in later years, it is very doubtful if it is of any great service to the individual, since ptyalin can only act in an alkaline medium, and as soon as the food reaches the stomach the acidity attendant on gastric digestion inhibits this action.

The Stomach of the Infant.—The stomach of the infant in early life presents few of the characteristics of the adult organ. The muscular wall is poorly developed, especially in the neighbourhood of the fundus. The relative amount of muscle tissue characteristic of the adult is not reached until about the end of the first year. The cells connected with the secretion of the gastric juice, both the central and the oxyntic, are less numerous, while the mucous glands are more numerous than in adult life.

The position of the stomach in relation to the body is nearly vertical, and the shape, owing to the slight development of the fundus and of the greater curvature, is tubular. Peristalsis is comparatively feeble, but the stomach completely empties itself in about two hours, the greater portion of its contents being disposed of by the stomach under the hour.

Despite the weakness of the gastric muscles, vomiting is more easily effected than in the adult, by reason of the

---

of Children'; and Fenwick, 'Disorders of Digestion in Infancy and Childhood,' 1897.

weak resistance of the cardiac sphincter, the tubular shape of the stomach, and the fluid condition of its contents.

Gastric Capacity.—The gastric capacity is of importance in relation to the regulation of the feeding of the young infant; hence, while the rate of peristalsis more or less determines the intervals of feeding, the gastric capacity determines the amount of each feed, since it may be assumed that, generally, the infant is not satisfied until the stomach is moderately distended. The many facts of clinical experience, together with the observations of the size of the stomach, seem to demonstrate very clearly that in the young infant satisfaction of hunger and the filling of the stomach so that it is distended almost to its complete extent, short of dilatation, are practically in close correspondence. The regurgitation of a small amount shortly after a meal must be regarded as the natural ejection of an excess leading to uncomfortable distension; hence the remaining contents may be regarded as representing the gastric capacity, for the time being, of the individual infant.

The actual gastric capacity is probably less than the amount of food taken, for it may be assumed that as food escapes through the cardiac orifice at the end of a meal, and is vomited, so the ingested milk during the meal may pass into the duodenum. In the case of infants requiring exceptionally large amounts, this, in all probability, regularly occurs.

No method of estimating the gastric capacity by the quantity of food taken can be regarded as representing the actual capacity, since various factors interfere with the accuracy of the observation. If we take the amount of food ingested at every meal, this is open to the doubt as to whether the full quantity representing the maximum capacity was received by the infant, and, on the other hand, the estimate must be affected by the probability of milk being rapidly poured into the duodenum. Measure-

ments taken on the cadaver scarcely prove the capacity during life.

From investigations carried out on the normal living infant results have been obtained which are sufficiently definite to afford valuable indications as to the normal amount of food required. The practical test is carried out as follows: A healthy mother having plenty of good milk, with an infant of normal size, weight and appetite, is selected. The infant is carefully weighed, and is then allowed to take the breast until it is satisfied. The infant is then weighed again, and the increase of weight is taken as representing the weight of milk ingested.

This test is far more reliable than the results to be deduced from the examination of the cadaver, for it is practically impossible to determine in the case of post-mortem tests where normal distension ends and dilatation begins. Hence the figures derived from post-mortem results are almost always higher than those recorded by the clinical method.

Rotch has shown the average actual gastric capacity by reference to the actual amounts of milk mixtures taken by a large number of infants. The following figures show the average amounts taken by 774 infants fed from the milk laboratories, from birth to the end of the first year of life:

AVERAGE ACTUAL GASTRIC CAPACITY.

Age.						Ounces.
1 day to 4 weeks, average amount fed					-	0·988 to 2·355
4 weeks to 8 weeks, average amount fed					-	2·355 to 3·220
8	„	12	„	„	-	3·220 to 3·969
12	„	16	„	„	-	3·969 to 4·574
16	„	20	„	„	-	4·574 to 5·284
20	„	24	„	„	-	5·284 to 5·719
24	„	28	„	„	-	5·719 to 6·187
28	„	32	„	„	-	6·187 to 6·953
32	„	36	„	„	-	6·953 to 7·544
36	„	40	„	„	-	7·544 to 7·894
40	„	44	„	„	-	7·894 to 8·071
44	„	48	„	„	-	8·071 to 8·231
48	„	52	„	„	-	8·231 to 8·254

In this country the average would probably be somewhat higher, as it is noticeable that in regard to the average birth weight and rate of gain the healthy American infant appears to be somewhat less vigorous than the healthy English infant.

Growth of the Stomach.—The growth of the stomach is very rapid in the first three months, slow during the next three months, and after this age the capacity gradually increases.

Frolowsky, taking 1 as the figure representing the gastric capacity for the first week, represents its increase as follows:

INCREASE IN GASTRIC CAPACITY.

First week - - -	1
Fourth week - - -	$2\frac{1}{2}$
Eighth week - - -	$3\frac{1}{5}$
Twelfth week - - -	$3\frac{1}{3}$
Sixteenth week - - -	$3\frac{4}{7}$
Twentieth week - - -	$3\frac{3}{5}$

The rapid increase in the first eight weeks is in marked contrast with the later development.

The age of the infant is, however, an extremely unreliable basis for estimation. The two most constant factors determining the capacity of the stomach are the *weight* of the infant and the *length* of the trunk. It is stated by many authors that the gastric capacity is higher in those infants artificially fed than those that are entirely breast-fed. As Rotch points out, this is an extremely noteworthy observation, since it emphasizes one of the commonest factors in substitute feeding—that of overfeeding. It is difficult to believe that, with adequate substitute food, a greater gastric capacity is required for this than for human milk.

The chief practical points in relation to gastric capacity are:

1. The necessity for frequent increase of amount in the early months.

2. The comparative permanence of capacity during the sixth to the eighth month.

3. The gradual increase of capacity at the end of this period.

In individual cases these rules may be departed from very considerably. Certain infants require much larger amounts than the average in the first three months. These instances are almost invariably associated with digestions only capable of dealing with exceptionally dilute mixtures. It is probable, in these cases, that the food passes more quickly than usual into the duodenum. The demand for a quantity in excess of the average amount is not maintained in the later months.

Gastric Digestion.—The processes of gastric digestion in the infant are related to the character of the diet and the primitive development of the stomach.

In less than a quarter of an hour, under normal circumstances, the whole of the *caseinogen* present in the milk is precipitated in its solid form, *casein*. This precipitation is brought about by the *rennin ferment*, which is constantly present in the infant's stomach already formed. In the adult it only appears to exist in an antecedent condition, and an acid solution is necessary for its development. In the case of the infant, the gastric juice is neutral or slightly alkaline at the beginning of digestion, so that acidity of the gastric juice is not necessary for the formation of *casein*. As soon as this coagulation occurs, the ferment secreted by the pepsin cells acts on the casein so as to form soluble peptones. This process is, however, an elaborate one; and it is probable that many organic compounds, representing various complex reactions, are evolved. These changes are so various that there is much difference of opinion amongst observers as to the precise reactions which may be regarded as normal.

Hydrochloric Acid.—The absence of free hydrochloric acid is a striking feature of the gastric contents. This is

accounted for, to some extent, by the comparatively small amount secreted in early infancy; but, to a greater extent, by the great affinity of hydrochloric acid for casein and its subsidiary compounds. In virtue of these combinations, a variety of compounds of proteids and chlorine are formed of the nature of amido-acids. As digestion proceeds the hydrochloric acid is disengaged from these compounds, so that towards the end of digestion—that is, in about an hour and a half in quite young infants—a small amount of free hydrochloric acid may at times be present.

Excess of Caseinogen.—When the caseinogen is in excess, the casein is precipitated in the form of large lumps. Not only is the casein too great in amount relatively to the amount of hydrochloric acid secreted, but, owing to its coagulation in large masses, the chemical reactions are extremely imperfect.

The interference with normal digestion is increased by the fat, which, instead of being suspended as an emulsion, becomes entangled in the casein masses, so that these masses consist not merely of casein, but of an extremely indigestible combination of casein and fat.

Thus, digestion is altogether upset, and a variety of products are formed, some of them being almost poisonous in character. The sour vomiting of curdled lumps is the common result of these changes.

One of the common faults of milk mixtures modified at home is their indigestibility, owing to the relative excess of caseinogen. For the reason above stated, the interference with digestion is greatly intensified when fat is present in any considerable amount. In consequence of this, home modified mixtures are almost always notably deficient in fat, for it is found that, when a normal amount of fat is given, symptoms of sickness and gastric fermentation ensue. These effects, which are attributed to the fat, are in reality due to the excess of caseinogen interfering with the normal fat emulsion.

Lactalbumin is not precipitated by rennin, and thus remains in solution. In this condition the digestive glands readily deal with it; indeed, some authorities, notably Brücke, contend that the albumin is absorbed directly by both the gastric and intestinal mucous membranes. Whether this be true or not, there is no doubt that the lactalbumin is highly digestible, and that the difficulty of proteid digestion only occurs when, from the excess of caseinogen, the character of the proteid differs from that which is normally present in the infant's food.

Phases of Gastric Digestion.—Gastric digestion may be divided into three fairly distinct phases: In the first, the reaction is alkaline or neutral; the caseinogen is formed into casein by the action of the rennin ferment. In the second, which, in point of time, is not altogether distinct from the first, the casein reacts with pepsin and with the chlorides of the gastric secretion: lactic acid is formed, and the chyme becomes *acid*. In the third stage, gastric digestion and the expulsion of the stomach contents into the duodenum is practically complete, and free hydrochloric acid may be present.

Gastric Absorption.—The amount of food absorbed by the stomach is probably very small. Alcohol is absorbed readily, but water is not absorbed at all. Hutchison points out that the non-absorption of water by the stomach is incontestably established both by physiological experiment and by observations on patients suffering from obstruction at the outlet of the stomach. 'When water enters the stomach, it begins to flow out into the intestine almost at once, the process going on in little gushes through the pylorus until all the water has escaped.' Since the natural diet of the infant consists of nearly 90 per cent. of water, this fact is important.

While certain substances may be absorbed to some extent by the stomach, its chief function is that of a churn, in which many chemical processes take place so as

to bring the food elements into a condition suitable for intestinal digestion and absorption. The relative size of the stomach and the intestine clearly points in this direction; and Hutchison also draws attention to an important aspect of this question. The comparatively small absorptive power of the stomach allows of the neutralization or rejection of injurious substances before they have time to enter the blood or be passed on to the intestine.

As a result of normal gastric digestion, a food mixture of peculiar character passes through the pylorus into the duodenum. The casein is in the form of small coagulated masses, partly unmodified and partly in various complex forms, such as propeptone and peptone. These are mingled with various other bodies, the fatty acids, organic chloro-ammonia compounds, leucin, tyrosin, and carbon dioxide. The fat is unmodified, but some is still in emulsion, and some mixed with the clots of casein. The reaction of the mixture is now definitely acid, and this is due to the presence of lactic acid in considerable amount. In this reaction lactose is the primary element.

Intestinal Structure.—In common with the stomach, the intestinal canal of the infant presents some definite characteristics. The development of the muscular wall is poor, and peristalsis is in consequence liable to become slow or irregular. The duodenum is larger relatively in the infant than in the adult. Throughout the intestine the mucous membrane is well developed, the villi are highly vascular, and it is rich in lymphoid elments; the nerves are very numerous, though the myelin sheath is imperfect. Lieberkühn's glands are not so numerous as in the adult, but the mucous glands are well developed and secrete plentifully.

Intestinal Digestion.—In the early months, the absorptive power of the intestine is very great, while the secretions necessary to deal with elaborate food products are

deficient. Owing to the elaboration of the lacteal system the intestine is able to absorb everything that is required when presented in the form of the natural diet, so that the degree of digestive power requisite in the adult is not called for in the infant. The secretion of the intestinal glands is alkaline; this plays but little part in actual digestion, but is of great importance in neutralizing the acidity of the chyme and in establishing the normal alkalinity of the chyle, without which absorption and peristalsis would be greatly disordered.

Into the second part of the duodenum are poured the bile and the pancreatic secretion. In this latter there are two ferments present from birth—trypsin and steapsin. At about the sixth month amylopsin is present, but before this it is either absent or only exists occasionally and in very slight amount.

The secretion of bile is very free; indeed, this is present from the third month of intra-uterine life; its pigments, bilirubin and biliverdin, are plentiful, but the biliary acids, fat, and organic salts, are much less in relative quantity than in the adult. Bile must be regarded chiefly as an excretion. The antiseptic action attributed to it is highly problematical, and the emulsification of fat which has been attributed to it is effected by steapsin.

Meconium principally consists of biliary substances. Cholesterin, a constituent of bile, is found unaltered in the fæces.

The pancreatic secretion *trypsin* is the chief agent in the digestion of the proteids, while *steapsin* emulsifies the fats so that they are presented for absorption by the lacteals in a very finely-divided state. A considerable proportion of fat, however, is not absorbed, and the presence of an excess of fat over the amount demanded for nutrition is necessary in order to maintain the intestinal contents sufficiently soft.

It is probable that many of the processes of digestion

and absorption are promoted or assisted by enzymes. Judson and Gittings quote the statements of several observers. Marfan found an active ferment present in human milk capable of breaking up fat, which he termed *lipase*. It was also found to be present, though less active, in cow's milk. The conversion of lactose into lactic acid is attributed to the alleged ferment *lactase*, and numerous other observers have described ferments with diastatic and other properties. The existence of these bodies as definite ferments is doubtful, since it is probable that many of them are the results of bacterial development. The bacteria in the lower parts of the intestinal tract are so numerous that it is impossible that they can live and multiply without being responsible for many chemical changes in the products in which they develop.

Intestinal Excretion.—The intestinal excretion of the infant during the twenty-four hours after birth consists entirely of that peculiar substance to which the name *meconium* is given, and which is never met with except in the case of the fœtus or newly-born infant. In colour it is generally dark olive-green, sometimes being almost black. It is without odour, viscid, and its reaction is slightly acid. It consists of epithelial cells which have desquamated from the intestinal mucous membrane, mucus, bile pigments, together with leucocytes and crystals of cholesterin. Fat is present, and is probably derived from the vernix caseosa. Normal meconium is invariably sterile. The total amount excreted by the infant is usually between 2 and 3 ounces. While the bulk of the meconium is generally passed in about the first two days of life, traces of it may occur for some days, and the motions of the infant do not usually become of the normal character till towards the close of the first week of life.

The typical motions of the normal infant are of golden

colour; their consistence is that of soft paste, bearing a close resemblance to the appearance of thinly-mixed mustard. The odour is not very marked, but somewhat resembles that of stale milk; there is no fæcal odour, and this is not generally manifested until the infant receives food other than milk. The reaction is generally acid.

Intermingled in the motions are numerous fine granular masses, yellowish-white in colour, and composed chiefly of fat. These must not be confused either with the curds present in pathological conditions when the proteids are in excess of the infant's digestive capabilities or with the masses of pure fat associated with an excess of fat in the food. Fat, in the form of fat globules, fatty acids, and compounds with lime, is a prominent constituent of the motions. There are also present a great number of bacteria, many of them being directly associated with the processes of intestinal digestion.

The precise character and appearance of the stools is much modified by the diet. The yellow colour of the motions is due to bilirubin, which in the infant is generally found undecomposed. It may, however, be subjected to oxidation, when the colour becomes greenish-yellow, and it frequently happens that bilirubin changes to biliverdin on exposure to air, so that a normal yellow motion may become green soon after it has been passed.

Motions of a grass-green colour, associated, as they almost invariably are, with offensive odour, are definitely pathological; but it must not be assumed that in all cases a green-coloured motion is necessarily a sign of disorder. Just as the change of colour occurs in the motion soon after its passage, so the change may take place low down in the intestine, and this appears to be of comparatively frequent occurrence. The first part of a motion may be quite normal, whilst the last part may be green or greenish in colour, and *vice versâ*. Greenish motions are not necessarily pathological. In one case under the author's care

the infant's motions were usually partly green and partly yellow in colour. This infant did exceptionally well, doubling its birth weight in four months. Those cases, however, in which the colour is purely green and in which no yellow can be detected are nearly always pathological. The yellow colour is distinctly modified by the amount of fat in the food. A low fat percentage will give rise to motions of quite light-yellow colour, while a high fat percentage will cause the dejections to be of a rich yellow, with a tendency to become brown.

CHAPTER XI

THE DIET OF THE INFANT IN RELATION TO GROWTH AND HEALTH

THE young infant, by reason of its rapid growth, requires a diet different both in its character and in its constituents from that of the child or the adult.

The Diet required for Structure.—The fact that by the fifth month the infant, under normal circumstances, at least doubles its birth weight, and by twelve months of age at least trebles its original weight, shows development to be proceeding at a very rapid rate. Hence the first essential of the diet is that it should be of a character to meet the requirements of this rapid creation of new tissue. While, in the adult, food is required chiefly as fuel to be converted into energy, and, secondly, as building material to repair waste, in the infant the building up of a new organism is the prime factor. Upon the character of the materials supplied for this purpose depend the final structure of brain and liver, bone and muscle.

In the adult any deficiency or excess of nutritive material in a single meal is of comparatively small importance. The error is corrected by the variety of diet, and, since structure is complete, where disorder results, it finds its chief expression in digestive disturbance and general impairment of health. In the infant, any defect is immeasurably magnified by the practically constant character of the diet.

Effects of Imperfect Methods.—If the food does not accord with physiological requirements, there is little if any opportunity for compensation of the error. So far from the deficiency, in a given element, during one day being compensated for by a comparative excess on the following days, the probabilities are that the defect is intensified by a continuance of the same conditions. In the practice of substitute feeding, every mother or nurse relies upon some method of modifying cow's milk, and this particular practice, whatever its precise character may be, is carried out with but slight alterations throughout the most vital period of the infant's life. This emphasizes the extreme importance of insuring that the food administered is one answering all requirements.

Probably, the commonest defect in the ordinary domestic milk mixtures lies in the extremely inadequate amount of fat present. These mixtures are frequently found to contain only about 1 per cent. of fat instead of the normal 4 per cent. The effects of this defect are often insufficiently realized. In the case of an infant receiving the normal quantity of food at the usual intervals, the deprivation of fat, when the mixture contains but 1 per cent. of this constituent, would amount, approximately, in six months to eight pounds of pure fat —an amount rather in excess of the average weight of the full-term infant at birth. The effects of such a deprivation occurring at such a vital period of development must necessarily have a profound influence on the tissues.

The attitude of those responsible for the care of the infant is often one in which all such considerations are ignored, and they are quite content when the mixture satisfies the first requirement only—namely, that it is tolerated by the infant's stomach. Indeed, many of the most inadequate mixtures are made use of as a result of this attitude.

When a mixture of equal parts of cow's milk and water is given to the infant, it frequently causes severe gastric and intestinal disturbance, due to the excessive amount and improper character of the proteids present. In order to reduce the proportion of these, the milk is further diluted to, for instance, one part of milk with two of water. If this succeeds, then the infant's digestion has been to some extent met at the expense of its nutrition, for in the first dilution the fat was already deficient, and in the second it has been reduced to but a fraction of that required.

The dietetic problem of infant feeding is a twofold one: To provide the infant with (1) an adequate supply of the materials physiologically necessary, (2) in a form capable of being digested and absorbed. It cannot be solved when either of these two essentials is neglected.

In reference to defective nutrition, two groups may be broadly distinguished: Those primarily affecting structural growth and development, and those primarily affecting the digestive system. In the presence of acute disorder of the digestion, it may be necessary for the time to exclude the wider considerations till the acute local symptoms have been treated. But the aim of the physician must always be to provide the infant with a food capable of yielding the materials in a form capable of absorption, and in kind and quantity adapted to the requirements of normal development.

Pathological features occurring in the course of growth arise chiefly from deficient intake of essential material. Excess of food, or the presence in the diet of improper materials, gives rise primarily to disorders of the digestive system, though, as a later result, these may be followed by systemic defect. Very frequently, in the food of the infant deficiency of necessary material coexists with the presence of injurious foreign matter.

Those faults affecting structure are the more serious

since the resulting defects in the bone, brain, and the various organs only gradually become definitely established, so that great harm may be done before the injuries are so manifest as to be recognisable by inspection and palpation. Comparatively slight intestinal disorder immediately provokes, or should provoke, comment. Such disorder is seldom, if ever, insidious either in its onset or symptoms.

In correspondence with the rapid anabolism of the infant, the diet must contain a much greater proportion of the tissue-builders than the diet of the adult, while, as the muscular activity is for some time very limited, the energy-producers are required in less proportion. These factors find their practical expression in the relative composition of human milk.

Limitations of the Infant's Diet. — The proximate principles of food consist of water, albuminoids, carbohydrates, fats, and salts. The limitations as to the precise form of these constituents in regard to the infant are much more severe than in the adult. For the adult the albuminoids include extremely numerous varieties, and the source of his carbohydrates is almost equally varied; for the infant the kinds are precisely limited to those found in milk, and are practically confined to two forms of albuminoid material in certain proportions and to one form of carbohydrate.

Water.—More than three-fourths of the whole body consists of water, and it constitutes over 80 per cent. of milk. Its function is that of a solvent and diluent, essential to all the chemical processes associated with life. A sufficient amount is necessary for the circulation and the activity of the cells.

In the stomach it prevents the undue concentration of food, and is of great importance in keeping the intestinal contents sufficiently liquid, so as to permit of their free evacuation. In many diseases—especially in rachitis,

where the sweating is frequently excessive—in cases where the temperature is raised, and in marasmus, to keep the blood as fluid as possible, the need for water is great, and this should always be freely supplied. The emaciation and collapse which so rapidly ensue in the diarrhœa of enteritis are largely due to loss of fluid.

The need for water is often shown by the infant in the first day or two of life, before the mother is able to furnish it with milk. Infants frequently suffer considerably from this lack of fluid, and are easily satisfied with a little water given by a spoon. The relatively great body surface of the infant also points to the need for a plentiful supply of fluid, since so much is lost in perspiration.

Uric acid staining is frequently a marked feature of the urine in the early days of life, and is an indication that the infant has not received a sufficient supply of water to enable the kidneys to perform their functions perfectly. Uric acid infarcts in the kidney are of not very uncommon occurrence, and, generally speaking, the urine in the new-born infant is characterized by its high specific gravity. Renal colic from the same cause may arise, though, as a rule, in very young infants it is usually impossible to diagnose such a cause with certainty; but in those cases where there is evidence of acute suffering in the first forty-eight hours after birth the possibility of this should be remembered.

The author invariably provides for this necessity of the infant by the supply of a very dilute milk. As a rule it is taken with avidity, and this desire of the infant may be accepted as a physiological indication of its need.

In the first forty-eight hours of life, the need of the infant is for water rather than for milk, and this want of the infant appears to be frequently unrecognised. Almost the whole of the nitrogenous waste and its derivatives are excreted by the kidneys, and, as many of these are but sparingly soluble, water in plenty is a necessity. It is

also requisite for the normal circulation of the blood, lymph and chyle.

In gastric digestion water plays an important part. The secretion both of pepsin and of hydrochloric acid is only fully accomplished when this is present in normal amount, and the chemical changes prior to absorption cannot be carried out without the free supply of a neutral solvent.

The Proteids.—In the structure of all living cells, protoplasm is the primary feature, and, while it is impossible to state the exact nature of protoplasm, since this only exists in the living form, the proteids are invariably obtained when dead protoplasm is analyzed. In common with all animals, and in contrast with the vegetable kingdom, man is unable to construct proteid from its constituent elements, and must be supplied with this already manufactured. And, in contrast to the adult, the proteids suitable for the infant are practically limited to caseinogen and lactalbumin.

Chemical Composition of Proteids.—In the present state of our knowledge no definite chemical composition can be assigned to proteids; that is, they cannot be represented by any formula indicating their molecular composition. On the other hand, their general percentage composition invariably lies within certain limits. The figures of Hoppe-Seyler and Drechsel have been generally accepted as indicating their composition.[1]

	Hoppe-Seyler.	Drechsel.
Carbon	50·0 to 55·0	50·0 to 55·0
Hydrogen	6·9 to 7·3	6·8 to 7·3
Nitrogen	15·0 to 18·0	15·4 to 18·2
Oxygen	20·0 to 23·5	22·8 to 24·1
Sulphur	0·3 to 2·0	0·4 to 5·0

The above table shows that, in the primal elements constituting proteid, there is comparatively little variation.

[1] Quoted from 'The Chemical Basis of the Animal Body' (Sheridan Lea).

But, in addition to these elements, the various forms contain varying amounts of mineral acid combined with metallic bases. Potassium, sodium, calcium, magnesium, and iron, are present in combination with carbonic, phosphoric and sulphuric acid. Indeed, there is some reason for supposing that, in the living condition, the proteids are present entirely in combination with salts, the combination, however, being broken up either by the death of the tissues or by the methods employed in the analysis.

Classification of Proteids.—The careful experiments and researches of many observers have enabled us to appreciate the fact that there are essential differences, both physical and chemical, in the constitution of various proteid materials. Sheridan Lea[1] has classified the proteids into certain groups, of which the following are of interest in the present connection:

1. *Native Albumins.*—Soluble in distilled water. Solution coagulated by heat, especially in the presence of dilute acid. Not precipitated by alkaline carbonates or by sodium chloride. Lactalbumin is an example of this class.
2. *Derived Albumins.*—Insoluble in distilled water; soluble in acids and alkalies. Not coagulated by boiling. Caseinogen belongs to this class, though differing in some respects from the other members.
3. *Globulins.*—Insoluble in distilled water; soluble in dilute saline solutions. Readily precipitated by saturating their dilute saline solutions with sodium chloride or magnesium sulphate. Lacto-globulin belongs to this class.
4. *Fibrins.*—Insoluble in water; soluble with difficulty in strong acids.
5. *Coagulated Proteids.*—Products of the action of heat on Classes 1 and 3.
6. *Albumoses and Peptones.*—The peptones are extremely soluble in water. They are not precipitated by acids, alkalies, or by neutral salts. Some of the albumoses are readily soluble in water, others are less soluble. They are precipitated by saturation with neutral ammonium sulphate.

---

[1] *Op. cit.*

Though we are not able to determine the precise nature of the chemical differentiations which account for these widely differing reactions, we can at least appreciate the fact that these reactions must be represented by definite differences of composition. The greater our ignorance is on these points, the more must we be bound by the limitations of observed facts. It cannot be disputed that marked differences, both in regard to physical properties and chemical composition, are exhibited by the bodies belonging to the proteid group, and that, for instance, the differences between caseinogen, lactalbumin, and other forms of proteid, are scarcely less than the differences between many bodies completely distinguished from one another in chemical nomenclature. Thus, in relation to infant feeding, the term 'proteid' is not sufficiently precise. The forms found in human milk must alone be the criterion in relation to the young infant.

The Effects of Deficient Proteid. — A deficiency of proteid in the diet affects the whole of the tissues, and the general character of the injuries resulting from this deprivation is essentially the same in all the organs. Since these defects are not usually recognised till they have passed from the microscopic to the macroscopic, the management of the diet must here be eminently prophylactic in order to insure the supply of a normal amount in the food mixture. For a considerable time, the infant may maintain a surprising amount of vigour together with increase of weight on a diet rich in carbohydrates but deficient in proteids.

The absence of the proper amount of proteid is seldom the cause of digestive disturbance, since in the ordinary milk mixtures it is the albuminoids which most commonly give rise to difficulty, owing to the excess of caseinogen and the deficiency of lactalbumin. In home modification the constant tendency is towards an extreme dilution of

the milk to overcome the difficulty caused by the disproportionate amount of caseinogen.

The baby so often put forward as the picture of health is very commonly found to be extremely fat and chubby, but the actual condition of the infant tells a very different tale to the experienced observer. These cases frequently present undoubted signs of rachitis well established, but the infants are generally too young to show the gross lesions of bone which must inevitably appear later. Hence they are regarded as healthy, and the excessive amount of fat, generally due to a great excess of carbohydrates, is almost universally regarded as a particularly good sign, whereas it is in fact quite pathological, and is almost invariably associated with a markedly atonic condition of the muscles, ligaments, and other tissues.

When the proteid-supply has for some time been deficient, the effects are widely distributed. The blood is affected very early, its specific gravity is diminished, and the hæmoglobin falls rapidly, often falling below 50 per cent. of the normal amount.

The red cells are also diminished in number. In cases which are at all severe these cells are much changed in form and size (poikilocytes), while nucleated red cells (hæmatoblasts) are present, and the leucocytes are generally increased in number.

These profound changes in the character of the blood are attended by numerous changes in the whole of the tissues. It is probable that the blood is first affected, and that the signs and symptoms are primarily dependent on the alteration in the blood. It may be, however, that the primary affection begins in the bone-marrow and spleen. When the anæmia is established the infant is pallid, the muscles are soft and very atonic, the normal growth of bone is greatly altered, the cerebral and spinal nervous system is unstable, and the manifesta-

tions of pathological irritability and fretfulness are frequent. Severe headache and pains in the limbs are not infrequently met with. On auscultation of the heart, hæmic murmurs may be heard, and œdema of the tissues occurs in some cases.

Effects of Excess of Proteid.—An excessive amount or a wrong type of proteid is one of the commonest causes of serious gastric and intestinal disturbance in the young infant. Frequent vomiting, colic, flatulence, with green offensive motions, are some of the striking clinical signs. Constipation may be present at first, but when the excess is great the irritation generally leads to the onset of diarrhœa. It is important in these cases that the defect in the food should be dealt with; but when the intestinal disorder is severe it is not only the food that has to be altered. The stomach and intestine are in a pathological condition by reason of the fermentative action of micro-organisms, and this requires appropriate treatment before the normal diet of health can be digested and absorbed. Moreover, it may be a *qualitative* excess with which we have to deal rather than a *quantitative* excess. The following case illustrates this:

An infant, three months old, had been suffering for some time from vomiting, colic, and alternation of constipation with diarrhœa accompanied by green and offensive motions. During the last week the infant had become much worse, and had lost 8 ounces in weight. The author was then consulted in reference to the case. It was evident that the food supplied was responsible for the condition. The mixture used was a domestic modification of cow's milk. A feed was made up by the nurse, and this was analyzed. The analysis of the specimen showed the following composition:

	Per Cent.
Fat - - - - -	1·15
Sugar (chiefly cane-sugar)	8·50
Albuminoids - - -	1·20

The stomach was washed out; castor-oil (2 drachms) was administered, and this was followed by three doses of calomel ($\frac{1}{8}$ grain).

During the first two days after the treatment the infant was fed on a milk according to the following prescription :

℞	Per Cent.
Fat	2·50
Lactose	5·50
Whey proteids	0·50
Caseinogen	0·25
Lime-water	5·00

Heat at 150° F. Eight feedings, each containing 4 ounces.

The infant rapidly improved, and the mixture was strengthened in all its elements. At the end of a week the infant was taking well, and making very satisfactory progress on, the mixture according to the prescription following :

℞	Per Cent.
Fat	3·50
Lactose	6·50
Whey proteids	0·75
Caseinogen	0·50
Lime-water	5·00

Heat at 150° F. Eight feedings, each containing 4 ounces.

This case well illustrates the fact that the mere amount of proteid only constitutes one of the factors. Within a week of the illness the infant was digesting well a mixture containing an amount of proteid slightly in excess of the amount in the domestic mixture, but differing greatly from it in quality, owing to the predominance of the whey proteids.

In breast feeding much disturbance is caused by variations occurring in the proteid content of the milk, calling for careful management of the mother both in regard to diet and exercise. These factors have been discussed in reference to the management of lactation. Intolerance of caseinogen is the chief characteristic of digestive disorders arising from the proteids. In substitute feeding, this difficulty should be met by supplying the requisite amount of proteid in the form of whey proteids combined with but a small proportion of caseinogen.

Fat.—The part played by fat is one that is f overlooked in the feeding of infants, and its deficiency is the explanation of much disorder and disease. With the onset of disorder in the nursing mother, the fat is at once affected, and the rapid deterioration of human milk in this respect is very striking. In the cow, the percentage of fat in the milk is about the same as in human milk, though with a tendency to be slightly below this percentage. The artificial proprietary foods, while they possess almost innumerable faults and contain much excess of certain constituents, are invariably deficient in this important element.

The maintenance of the normal degree of animal heat in the young infant is of the first importance. In many cases, especially in ill-health, the loss of heat is greater than the heat produced, and, in consequence, all the functions are interfered with. The extremities naturally show the most marked evidence of this loss of animal heat, so that 'cold feet' is one of the cardinal signs of the condition.

Since a free amount of muscular exercise is impossible in the case of the young infant, it depends almost entirely upon its food as the heat-producer, and thus upon those constituents connected with this function—fat and lactose. Of these, fat is much the more powerful of the two in the production of heat. In human milk, the proportion of fat is nearly three times as great as the proteid elements.

Fats are deficient in oxygen, but rich in carbon and hydrogen, which both have a very great affinity for oxygen. In lactose the amount of carbon is nearly equalled by that of oxygen, as is seen by its formula —$C_{12}H_{22}O_{11} + H_2O$. The chief fats in human milk are compounds of glycerine, with oleic acid, palmitic acid, and stearic acid, forming olein, palmitin, and stearin. The large amount of carbon available for oxidation is shown by their formulæ :

Olein - -	$C_3H_5(C_{17}H_{35}CO.O)_3$
Palmitin - -	$C_3H_5(C_{17}H_{31}CO.O)_3$
Stearin - -	$C_3H_5(C_{17}H_{35}CO.O)_3$

These formulæ demonstrate how essential is fat to the organism, and especially to the infant. It presents carbon in an unoxidized, but highly oxidizable, condition, whereas the carbon presented in the form of carbohydrates is already highly oxidized, and is therefore of little avail for chemical combination with oxygen.

But it cannot be assumed that this oxidation of carbon is a simple chemical process of combination so as to form carbon dioxide. This is the ultimate result of elaborate processes, in the course of which almost innumerable products essential to the organism are evolved. The majority of these products are combinations of fat and proteid in the shape of complex nitrogenous fats. Lecithin ($C_{44}H_{90}NPO_9$) occurs in the red corpuscles and bile, while it is an important constituent in the brain, nerves, and white blood corpuscles. Cerebrin ($C_{17}H_{33}NO_3$), an important constituent of the brain and nervous system, is another example of the kind. The essential feature of fat is illustrated in the part played by the stearin of human milk in reference to lecithin :

$$\underset{\text{Lecithin}}{C_{44}H_{90}NPO_9} + 3H_2O = 2\underset{\text{Stearic acid}}{C_{18}H_{36}O_2} + \underset{\text{Glycerin-phosphoric acid}}{C_3H_9PO_6} + \underset{\text{Cholin}}{C_5H_{15}NO_2}.$$

These chemical facts are especially important in reference to the effects on nutrition of a diet deficient in fat. The results of chemical analysis and clinical observation confirm each other.

Neither adipose tissue nor the complex nitrogenous fats are necessarily directly derived from the fat supplied as food. Many experimental observations have been made which go to show that adipose tissue may be derived from both proteid and carbohydrate. Clinical observations show most definitely that the deposit of adipose tissue is

more likely to occur on a diet deficient in fat, but containing an excess of carbohydrate.

Specific Effects of a Deficiency of Fat.—Deficiency of fat in the infant's diet leads to serious results. The insufficient heat generated has already been referred to, and this may contribute towards the other effects. Though, in the etiology of rachitis, many other factors play their part, the absence of sufficient fat in the diet is probably the primary cause. There are also numerous symptoms in the alimentary tract due to the same cause. Constipation is usually present, associated with a somewhat chronic indigestion, as indicated by gastric and intestinal pain in the intervals between feeding. The symptoms are not, as a rule, acute, and consequently may fail for some time to attract any marked attention.

The course of the general development is slow, teething is delayed, the mental faculties are feeble, and the brightness and intelligent appearance of the healthy infant are absent. Speech is consequently delayed, and, in general, the faculties of perception and observation are imperfectly developed.

There is good reason for thinking that many of the neuroses in children and adults owe their origin to defective diet in infancy, and especially to the fact that the nervous system has suffered in consequence of the inadequate amount of fat in the diet.

The high development of the physiological structures for the absorption of this element in the infant and the large amount present in human milk are both facts indicating strongly the physiological necessity. Ninety per cent. of the fat taken is absorbed by the intestinal villi, and the surplus is of importance in affording a lubricant facilitating the expulsion of the fæcal matter.

When the fat in the diet is not merely deficient, but so small in quantity as to be less than one-third of the proper amount, the signs are more acute, and the wasting and

weakness are usually pronounced. In these cases the development of rachitis is almost certain if the defect is not speedily corrected.

Excess of Fat.—Effects due to the excess of fat are occasionally met with. Sickness soon after feeding, and diarrhœa with green motions, are the commonest symptoms associated with this. It has already been remarked that a high fat and high proteid content tend to be antagonistic. In these cases the symptoms may disappear on a reduction in the amount of the proteids.

Lactose.—Lactose is the only form of carbohydrate present in milk, and is therefore the only form suitable for the infant. Other forms of sugar (cane-sugar, maltose, glucose, etc.) are very largely used in place of lactose, and give rise to a great deal of intestinal disturbance. The chemical properties of milk-sugar are peculiar to itself. It plays an essential and important part in the production of lactic acid; without it the lactic acid bacilli, which have been previously discussed, cannot act, and the normal processes of intestinal digestion are altogether perverted.

Butyric acid fermentation may take place in the case of starch, dextrins, cane-sugar, etc. Lactose does not undergo this change. Cane-sugar undergoes alcoholic fermentation, but yeast has no action on milk-sugar. Cane-sugar, maltose, etc., favour putrefactive changes, with decomposition and fermentation of the intestinal contents. Lactose is incapable of these reactions, and by its co-operation with the hygienic bacilli possesses a function directly antagonistic to putrefactive changes.[1]

Symptoms of intestinal irritation, in the shape of

[1] '. . . Since lactose is incapable of direct (alcoholic) fermentation, not only is the milk while it is accumulated in the breast less liable to fermentative decomposition, but also the tendency to fermentative disturbance in the alimentary canal of the young animal is largely diminished' ('The Chemical Basis of the Animal Body').

diarrhœa and of skin eruptions, are frequently seen in infants when their diet contains cane-sugar or maltose and other forms of carbohydrate in excess. Certain preparations containing a large amount of maltose are particularly associated with these disorders. Occasionally lactose may be actually or comparatively in excess, and this may give rise to diarrhœa. This is, however, rarely seen, as it is not a common result of a trifling excess, and cases where lactose has been given in an abnormal amount are uncommon.

CHAPTER XII

THE NORMAL DEVELOPMENT AND THE GENERAL EXAMINATION OF THE INFANT

In order to arrive at a right estimate of the condition of an infant, it is necessary that the degree of development proper to the particular age should be determined as accurately as possible. The rate of growth and the many changes that take place in the young infant are so peculiar to this period of life that these factors need special attention.

The Weight of the Infant.—The weight is one of the most valuable criteria, and is so important that a careful and systematic weight record should be kept whenever practicable. When this is done, it enables those responsible for the care of the infant to assess the comparative progress, or warns them of the possibility of some defect or disorder. For a few days after birth, a loss of weight occurs as a result of the voiding of meconium and urine, while the infant is taking practically no food. This loss of weight may largely be prevented, and the vitality of the infant more promptly established, by providing the infant with suitable food. When this is done, the loss of weight is very slight or inconsiderable, so that by the end of the first week of life an appreciable gain on the birth weight has been made. Where this is not done, the original weight is not regained till about seven days after birth.

During the first two months, the daily gain should not be less than two-thirds of an ounce. Cases where the gain

only amounts to half an ounce or less per diem must be regarded as unsatisfactory, and call for investigation, due allowance, however, being made for the circumstances of the particular infant. The following table shows the average increase in weight of the infant:

AVERAGE INCREASE IN WEIGHT DURING THE FIRST TWO YEARS.

Weight at birth	- - -	8 pounds.
" five months	- -	16 "
" one year	- -	21 "
" fifteen months	-	24 "
" two years	- -	38 "

These are figures derived from a large number of cases, which include many below the standard of perfect health. Vigorous infants well fed and cared for frequently develop at a much greater rate than that shown in the above table. The author has at the present time under his observation several cases illustrating this. One infant weighed at birth 7 pounds 13 ounces, and exceeded 21 pounds in weight at the end of six months. It was substitute-fed, by prescribed mixtures, from birth. Two infants, weighing respectively 7 pounds 10 ounces and 8 pounds 4 ounces at birth, both weighed nearly 20 pounds at six months of age. They were breast-fed throughout.

The Weight Record.—In recording the weight of the infant, a weight chart, corresponding somewhat to a temperature chart, may be used; this is useful, as in private cases the nurse is more likely to take due care in recording the weight than when this is omitted. As an aid, however, to graphic illustration its use can scarcely be compared in value with that of the temperature chart. Unless the chart is of exceptional and inconvenient dimensions, the daily gain in weight is not very strikingly shown.

In the author's experience, the character of the history, in regard to the weight, is more easily assessed by means of the actual figures recorded in a special column on the chart containing the other important particulars in

reference to the progress of the infant. This enables the whole of the salient features of the cases to be presented to the physician in a convenient compass. The form devised by the author for use at the Infants' Hospital is so arranged that the age of the infant, its weight, the nature of its diet, and any features calling for remark, are all systematically recorded on the same sheet.

The most convenient form of weighing-machine is that illustrated in Fig. 3. Whether it is as exact as other

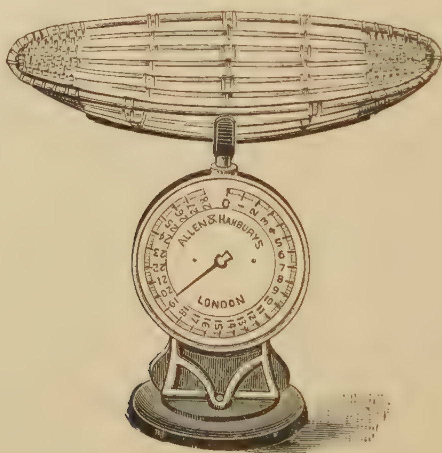

FIG. 3.—WEIGHING-MACHINE.

forms may be doubted, but this is of slight importance when the same machine is always used, and this should be insisted upon. The infant should be weighed at the same time of the day on each occasion. This is preferably after its bath, and it should be wrapped in a blanket the precise weight of which is known.

Some care is necessary to insure that the observation is taken with sufficient accuracy to be of use. Insufficiently trained nurses are notably careless in this respect, and exhibit a marked tendency to estimate the weight of the receiver and to neglect other necessary precautions.

The Length of the Infant.—Many other factors besides the increase of weight illustrate the rapid developmen occurring during infancy. The average length of the infant at full term may be regarded as about 20·5 inches. In the first six months this is increased by about 5 inches, or nearly an inch a month. During the following six months the growth is slightly less rapid, amounting to about 4 inches. The figures representing the increase of length during the period of rapid development are approximately as follows:

THE AVERAGE INCREASE IN LENGTH DURING THE FIRST THREE YEARS.

Length at birth	20·5 inches.
" six months	26·0 "
" one year	30·0 "
" two years	33·0 "
" three years	36·0 "

The Head, Trunk, and Extremities.—At birth the head and trunk are relatively long when compared with the extremities; while after birth the growth of the extremities proceeds at a much greater rate than that of the trunk as regards length. During this period, however, the breadth and capacity of the trunk undergo great increase. In the earliest weeks of life, the development of the circumference of the head and thorax is especially rapid. At birth the circumference of the head is about 13½ inches, and that of the thorax about 13 inches. The following table shows the approximate development:

THE AVERAGE GROWTH OF HEAD AND THORAX DURING THE FIRST TWO YEARS.

Age.	Circumference of Head.	Circumference of Thorax.
At birth	13½ inches	13 inches
" six weeks	16 "	15 "
" six months	17 "	16½ "
" nine months	18½ "	17½ "
" one year	19 "	19½ "
" two years	20 "	21 "

Facial Development.—At birth, the base of the skull,

the lower jaw, and the whole of the facial region, are extremely poorly developed. This disproportion between the face and the cranium is a distinctive characteristic of infancy. While in the adult the proportion of the face to the cranium is approximately as 1 to 2, in the full-term infant at birth it is as 1 to 8. The nasal bones are very poorly developed, so that, frequently, at their junction with the frontal bone, the bridge of the nose is quite absent. The development of the nasal bone proceeds rapidly after birth for the first nine months; after this period the process is much slower, and it is not till about the seventh year of life that the nasal bones and naso-pharnyx attain a development approximating to that of the adult.

The Fontanelles. — The fontanelles are of especial importance in regard to the estimation of the general condition of the infant. The anterior fontanelle undergoes little or no diminution during the first nine months; at about this period it begins to diminish in size, and should be obliterated by the end of the eighteenth month of life. As a rule, the patency of the anterior fontanelle after the twentieth month must be regarded as pathological. After the first twelve months the size of the fontanelle needs also to be considered; at this time the diameter should not exceed 1 inch, and should be proportionally diminished as the infant approaches the age of eighteen months.

When the fontanelle is distinctly more extensive than is normal for the age, this should be regarded with suspicion. Of the causes leading to delay in ossification of the sutures, rachitis is by far the most common. While delay in ossification of the cranial sutures usually affords strong evidence of pathological changes, the presence of rachitis should never be excluded on the ground that ossification in this situation does not present any defect. In some cases rachitis may be well marked, while the anterior fontanelle is either closed or does not exhibit any

departure from the normal standard. The posterior fontanelle is of very little practical importance; it is very small at birth, and in a week or two its outlines can scarcely be definitely distinguished. It is almost invariably completely closed before the end of the eighth week. In premature infants this fontanelle is much more distinct, and its complete closure may be delayed for several months.

Muscular and Nervous Development.—In regard to the general nervous and muscular development, certain facts are of importance. About the end of the twelfth week, or between this and the sixteenth week, the infant will stretch out its hands and grasp objects placed within its reach. Somewhat earlier than this, the head can be held erect when the body is supported. At about the age of seven months, the infant is generally able to sit up without any support. At first, it will only maintain this position for a few minutes at a time, but soon develops the power of maintaining the attitude, without fatigue, for a considerable period.

At eight or nine months of age, the first attempts at crawling are usually noticed. Before the power of standing erect is usually at all developed, the infant has used its legs freely, in conjunction with its arms, so that its powers of locomotion are very great. The power of standing depends not only on muscular strength, but on the development of the sense of equilibrium. Many of the infantile means of locomotion place quite as much strain upon the muscles of the lower extremities as standing or walking. The development of the function of maintaining equilibrium is one of education primarily concerned with the nervous system, and the age at which infants can stand or walk varies greatly. As a rule, the infant makes attempts to stand at about the age of one year. When this is satisfactorily accomplished, walking is soon undertaken, and by the fifteenth month the infant can walk for short distances without support. It is, how-

ever, some considerable time before the gait is steady and well balanced.

The Special Senses.—The development of the special senses in the young is extremely interesting, but the most prominent features can only be briefly noted here. In the newly-born infant vision, as understood in the adult, is almost completely absent. A bright light produces a painful stimulus, and the eyelids immediately close. At about the end of the first week of life, a light at some distance may induce the infant to turn its eyes in that direction, but to all other visual impressions it makes either a very feeble response or none at all.

Co-ordination of the muscles of the eye, for the purpose of bringing in focus a near or distant object, is almost entirely absent for some weeks, and only gradually develops. When this function is developing, the infant is seen to momentarily fix its eyes upon an object, but is unable to maintain the necessary co-ordination for any length of time. Recognition of objects is a complex process necessarily associated with mental development. It is not definitely established till about the sixth month of life. The various phases of the development of vision and visual recognition are best illustrated in the wards of an infants' hospital. The contrast between the infant one month old and the infant of six months is extremely marked, while the degrees of development are illustrated by the infants of intervening ages.

The auditory function in the newly-born infant does not exist. The author is not aware of a single case where, in the first twelve hours after birth, an infant has shown any evidence of hearing. The following is a curious instance demonstrating the absolute deafness of the newly-born infant. A glass tray full of instruments and carbolic lotions slipped on to a cement floor from the hands of the nurse carrying it. The loud crash for the moment alarmed everyone in the room. The infant, six hours

old, within two feet of the fallen tray, slept on quite undisturbed.

For some days the function of hearing remains very defective, while at the end of seven days it is usually fully established. It is then found to be extremely acute, so that the infant is easily awakened by any noise and is often upset by loud noises, as if they caused it pain.

The Tactile Sense.—The tactile and general nervous sensibility is very poorly developed in the young infant as compared with the child. External sensory stimuli are very imperfectly located and the precise situation of acute pain, caused, for instance, by a pin-prick, is but slowly recognised. For the same reason, the suffering from pain is seldom as acutely realized as in the older child.

The functions associated with sucking and with taste are extremely well developed. An infant will frequently refuse to take its food if it is not sufficiently sweetened or is not sufficiently warm. In regard to the taste of its food, the infant depends on its previous education. If it has been fed, for instance, on boiled milk throughout, it will not, as a rule, refuse this; but, if it has been fed on unboiled milk, and is then supplied with milk that has been boiled, it will probably refuse it.

At the Infants' Hospital, some difficulty is at first often met with in feeding the infants who have been brought up on the artificial foods. As many of these foods contain a great excess of sugar, the infants, accustomed to the sweet taste, reject the milk mixtures containing the normal amount of lactose. It is sometimes necessary, in consequence, to yield to this factor, for the time, by giving an abnormally large amount of lactose, and gradually diminishing it. As a rule, however, the infants are allowed to refuse until hunger compels them to yield, unless this is dangerous.

The acuteness of the taste is also illustrated by the

infant's recognition of any serious alteration in its food mixture. An infant fed on a divided proteid mixture will sometimes show distaste for a mixture in which the proteids have not been divided. As the taste is largely due to olfactory impressions, the function of smell must be developed; but, in regard to the development of this sense, irrespective of taste, there is little evidence.

Speech.—The infant begins to speak at about the end of the first year of life—that is, at about the same time that it begins to walk. Long before this, however, it has gained the power of expressing itself by sounds indicative of pleasure and annoyance. A happy and contented infant at about the sixth or seventh month of age will spend a large part of the day playing with toys and crowing to itself, much as a cat purrs. The close correspondence between these vocal expressions and those of speech may be best realized by watching a child of three years and an infant of six months playing together. The speech of the child is replied to by a variety of vocal sounds on the part of the infant, and the alterations of the child's words and intonations find their counterpart in the varying sounds and inflections of the infant's voice.

When about one year old, the infant pronounces the names of persons with whom it has been most intimately associated. 'Nanny,' 'Papa,' 'Mamma,' are usually the first words definitely pronounced. From about the eighteenth month, it begins to connect words together so as to form phrases. When it has reached this stage the progress is extremely rapid.

The evolution of the function of speech is extremely instructive, not only in regard to the development of the infant itself, but also in relation to the essential features of language. If this development be traced from the beginning, it will be found that the first words spoken are the names of persons; then come the names of

objects and of domestic animals. A comparatively rich vocabulary is then formed, consisting mainly of the names of persons, objects, etc. The nurse has usually only to indicate the person or the object to elicit the name. But no attempt is made to connect words with words.

The first sentences or phrases consist merely of words juxtaposed. Then these are combined with the verbs representing the simplest acts, and, very gradually, sentences of more and more elaborate construction are used. The words modifying names and acts are next introduced into the vocabulary; conjunctions and prepositions are added soon after; while the definite and indefinite articles are not used, as a rule, until infancy is passed. The personal pronouns are the last to appear, and are not used until the child has learnt to speak clearly and connectedly.

If, under normal circumstances, no attempt at speech has been made by an infant at eighteen months of age, some physical or mental defect is probably present, and if the inability is still present at two years of age, the existence of some defect of this character is almost certain. As a rule, the female infant, by reason of its greater intuition, learns to speak earlier than the male.

Dentition.—At birth the deciduous teeth are all formed, but they are situated beneath the submucous tissues of the gums. They grow, chiefly, by the deposition of osseous material at the roots, so that the teeth are gradually forced through the tissues. This dental development which has begun long before birth continues steadily afterwards, but the time at which the teeth emerge from the gums is subject to considerable variation, even in healthy infants. The time and order of their appearance are approximately as follows :

APPROXIMATE DATE OF APPEARANCE OF THE DECIDUOUS TEETH.

I.	6 to 9 months	-	2 lower central incisors.
II.	8 to 12 ,,	-	4 upper incisors.
III.	12 to 15 ,,	-	2 lower lateral incisors. 4 anterior molars.
IV.	18 to 24 ,,	-	4 canines.
V.	24 to 30 ,,	-	4 posterior molars.

An infant should have six teeth at one year of age, twelve teeth at eighteen months, sixteen teeth at two years, while the first dentition should be complete when the child is about two and a half years old.

The teeth, however, are by no means regular in the time and order of their appearance. In some cases teeth may appear as early as the fourth month; indeed, it is not very uncommon to find infants born with them. When at Queen Charlotte's Hospital, the author saw numerous instances of this.

In other cases, dentition may be late, and no teeth may appear till nearly the twelfth month. This does not necessarily imply any radical defect, but careful inquiry is advisable in such cases to determine that the nutrition of the infant is satisfactory, and that the delay in teething is not due to rachitis, which is by far the commonest explanation. As has been pointed out by various observers, rachitis is not always manifested in this direction, even when its other manifestations are severe. The author has seen numerous cases of advanced rachitis not presenting any evidence of delayed dentition.

General Examination.—When disorder is present, it is necessary, in order to insure accuracy and completeness of diagnosis, that the character of the development should be accurately estimated, and in the preliminary investigation due attention should be given to the chief factors above referred to.

In determining the nature of the disorder, the *history* of the case should be carefully investigated. The facts in

regard to the condition of the infant at birth, the character of the labour, the absence or presence of pressure symptoms soon after labour, need to be formulated as definitely as possible. The character of the diet must be thoroughly inquired into, as well as any digestive or other disorders associated with it. The weight record when available, and any fall in weight that has been noticed, must receive attention. At a later stage of the infant's life, the general rate of development should be ascertained by reference to the weight, the time the teeth appeared, the period at which the infant was able to sit up by itself, to stand, to walk, and to speak.

Coming to the present illness, all facts connected with its incidence need to be precisely defined. Here, much difficulty may be encountered, and especial care is needed to avoid placing too definite an interpretation upon statements which are frequently not intended to bear the meaning the words actually involve.

Accuracy of statement is frequently obliterated by the desire of the mother or nurse to impress the hearer with some phase of the disorder which is considered by them to be the essential element, but which is often merely a comparatively unimportant incident of the disorder. In consequence, there is a great tendency to lay undue emphasis upon certain facts, to the exclusion of others possibly much more important.

General Appearance.—The general appearance of the infant sometimes affords valuable indications. The character of the skin and complexion are often suggestive. The skin may be very dry or excessively moist; the face may be pallid, cachectic, or cyanosed. The cheeks and feet should be felt to determine whether they possess their normal warmth.

The facial expression is often a valuable indication. Instead of the calm and bright expression of health, the upper lip may be retracted, indicating abdominal pain; or

the eyebrows may be furrowed, indicating a more localized pain.

The Cry of the Infant.—The cry of the infant is not without its diagnostic value. It is the infant's chief means of expression, and the response varies with the stimulus.

The cry of discontent is perhaps the one most commonly heard. It is especially characteristic during the first few months of life, and must be distinguished from that associated with pain and illness. It may be largely contributed to by the mother or nurse constantly taking the infant from its cot, performing various gymnastic exercises with the infant, and talking to it in the well-known nursery jargon. Each nursery seems to have its own special traditions in the variety of amusements provided for the infant.

The result of these procedures is that the infant refuses to be contented in its cot until it is tired out. At most other times, when left in the cot, it immediately demands a renewal of attention. While the infant is crying from this cause, it is often difficult to determine its origin. It is, however, easily diagnosed by watching the infant when it has obtained what it wants. If the cry then ceases and the infant is happy, the nature of the plaint is clear.

In these cases, it is necessary to caution the nurse and all concerned with the care of the infant against the practice of constantly carrying and exciting the infant. It is extremely bad for the infant's nervous system, results in the infant getting far less sleep than it requires, and accounts for many of the more trivial digestive disturbances. The greater part of the young infant's life should be spent in sleeping and feeding, and the habit of crying because it is placed in the cot must be thoroughly broken. When it has been determined that the cry is of this character, the infant should be allowed to cry till it is tired, but not be taken from its bed. In a very short period, it will learn the futility of its lament and go to sleep.

The peevish, fretful cry of hunger is generally recognisable. It is not constant, and often ceases altogether for a short time when the infant is provided with something to suck. Frequently, it sucks its thumb or fist. The cry ceases as soon as the infant is provided with the food it needs in sufficient amount.

The cry of acute pain is characteristic—it is sharp and piercing, and is associated with contraction of the limbs and features. It is easy to see that something is hurting the baby severely; it may be internal, such as colic, or external, arising from injury from a safety-pin or other cause.

One of the most frequently misinterpreted cries is that of pain from indigestion. The cry itself is not so sharp as that of acute pain, and closely resembles that of hunger. Moreover, it frequently ceases for a few minutes after food. The food is given at about 100° F., and thus a little more warm food acts for the time as a fomentation. As soon as this action has ceased, the pain becomes increased and the crying is renewed. Discrimination must therefore be exercised, and an investigation of the case will determine the meaning of the plaint.

In some cases, acute gastric and intestinal indigestion is associated with a ravenous appetite. These are the cases of infants fed on food large in bulk, but containing starch, and, in other respects, altogether inadequate for nutrition.

Physical Examination.—In the examination of the infant some practical points are of importance. The temperature should be taken by the thermometer placed in the rectum. No other method can be relied upon. In the case of young infants, a raised temperature, in the absence of other signs, means very little. Moreover, the normal temperature of the infant may be as high as 99·5° F.; or, at any rate, this temperature may be found in the absence of any signs of disorder. A subnormal

temperature in an infant is much more serious than the rise of a degree or two.

As soon as the preliminary observations have been made, the infant should be completely stripped, and the whole body should be rapidly but systematically examined. This being completed, the infant should then be wrapped in a blanket, only those parts being exposed which require further examination. The preliminary examination of the naked infant should never be omitted, else some factor of the utmost importance may be altogether missed. It need hardly be said that precautions must be taken to prevent chill from exposure.

The head should be gently palpated, to determine the degree of ossification of the sutures and the condition of the anterior fontanelle. Tenderness of the limbs, especially of the legs, so that the infant cries on moderate pressure being applied to them, is a significant sign; while the general inspection of the limbs, chest, and abdomen, will enable the observer to determine, to some extent, the degree of nutrition or wasting, and to detect the presence of any of the characteristic signs of marasmus, scorbutus, or rachitis.

The heart and lungs may then be examined, though, in regard to nutritional disorders, these organs are only indirectly affected. The presence or absence, however, of concurrent disease—such, for instance, as congenital heart disease—must be determined. The abdomen requires careful attention. The presence or absence of flatulence, distension, ascites, general or localized tenderness, should be noted, and the position and size of the liver and spleen need to be carefully determined.

The mouth and throat should be inspected at quite the end of the examination, as the infant usually resents this more than anything else, and this should therefore be postponed till the other points have been decided.

CHAPTER XIII

. GASTRIC AND INTESTINAL DISORDER

The disorders of digestion vary from those trivial in themselves, and associated with slight temporary derangement, to those seriously endangering life, or so severe as to prove quickly fatal. Many of the grave conditions are the ultimate outcome of slight ailments allowed to continue uncorrected.

Overfeeding. — The minor complications of infant feeding are the source of great discomfort to the infant and interfere with its natural development. Overfeeding is one of the commonest causes of indigestion. The vigorous and hungry infant at the breast may, in a few minutes, swallow a much greater quantity of milk than can be dealt with by the stomach in the time.

Such instances are found where the mother has a large quantity of milk which flows more readily than usual, so that the infant is not restrained by the normal effort necessary to obtain its food. The infant is disturbed and restless after its meal, the food is regurgitated in considerable amount soon after nursing, and frequently it is continuously uncomfortable until a considerable quantity is suddenly vomited. One of the first necesssry inquiries in regard to the breast-fed infant is as to the duration of its feeding. From fifteen to twenty minutes should be the time given to feeding on each occasion, and where the milk flows too freely, precautions must be taken to

prevent the infant's stomach being overtaxed by the sudden ingestion of too large a quantity. It is also advisable to allow several intermissions in the feeding, so that the stomach may accommodate itself to the incoming milk and is not called upon to deal with too great bulk at any one time.

When the infant has once got into the habit of distending its stomach at each meal, the control of the nursing requires much care and perseverance. As soon as the infant begins to show signs that its hunger is appeased and is no longer vigorous in sucking, as at the outset, the feeding should be stopped. The fact that it cries on being taken from the breast, as if not satisfied, must not be allowed to interfere with this procedure, since it is necessary to break the habit of overfeeding, and, until this is broken, the disorder will not cease.

If this constant overdistension is allowed to continue, atony of the stomach ensues with dilatation. In consequence, a large amount of milk lies in the stomach undergoing putrefactive changes and normal digestion becomes seriously perverted.

The secretory activity of the gastric cells and the peristalsis of the muscular wall are both enfeebled, so that a large amount of decomposing milk and its products are present, and the stomach is never empty. The infant is sorely troubled with constant flatulence and regurgitation of sour milk ; definite vomiting may occur, but, as a rule, in this class of case, it is not a prominent symptom owing to the atony of the stomach.

The above conditions appear even more commonly in bottle-fed infants, and are frequently due to the same cause. The treatment lies in the regulation of the amount of food taken and in the systematic control of the feeding.

In the case of breast feeding, the passage of the milk should be regulated by the mother compressing the nipple between her fingers, so that the infant is only able to

obtain a gradual supply. This method has another advantage: the process of sucking demands considerable effort on the part of the infant and the degree of fatigue is probably one of the factors inducing the infant to relinquish vigorous sucking.

In bottle feeding, the same principle must be observed. The rubber teat must be provided with an outlet small and resistant, in order that effort is required on the part of the infant to obtain its food, so that the amount obtained is not more than it should receive. The nurse can also easily regulate the amount by maintaining the bottle at an elevation which only permits the passage of a moderate quantity.

Gastric Dilatation.—Where definite dilatation of the stomach has occurred as the result of the continuous neglect of these precautions, it is necessary to resort to thorough measures. Food must only be given in small quantities, and the deficiency of each feed must be compensated for by increased frequency of feeding.

Effects of Gastric Dilatation.—When dilatation of the stomach has persisted for some time, treatment is tedious and difficult and a large number of cases are seen where the affection has become chronic.

The infant is pallid, smells sour, and is clearly very much out of health. It gains weight slowly or not at all, and the digestion is perverse. The mother or nurse has resorted to the most dilute mixtures, such as condensed milk diluted some fifteen times, since foods richer than this have proved to be too much for the infant's digestion. Great perseverance and systematic attention are required to bring these infants back to a normal condition, and the greatest refinements of substitute feeding may be necessary.

At any time, the chronic disorder may develop into acute gastro-intestinal infection as a result of putrefaction of the food. When this occurs, the prognosis is grave. The

chronic ill-health of the infant has very gravely impaired its power of resistance and a fatal result may rapidly ensue.

Other errors, either in the quality or quantity of the diet, may be responsible for disturbance of some part of the digestive apparatus, and these, at first, may not be associated with any great degree of general disorder.

Vomiting.—Vomiting may arise, indicating some defect in the breast milk or the imperfect adjustment of the substitute food. In the case of bottle-fed infants, this frequently leads to the rejection by the mother or nurse of an improperly modified cow's milk in favour of a preparation which the infant can digest, but which is gravely deficient in nutritive properties. The statement that the infant 'cannot take cow's milk' is the almost constant explanation of the fact that the infant is being fed on a condensed milk or other artificial food. If the individual factors of these cases are properly appreciated, there is usually very little difficulty in providing a modified milk adequately meeting the indications.

Diarrhœa.—An abnormal frequency of the motions, without any marked signs of enteritis or other disorder, may arise from defect in the food. Excess of fat or the presence of some irritant in the food may be the cause. Infants fed on artificial foods containing large amounts of maltose are frequently attacked with diarrhœa. In these cases excess of fat is never the cause, as this element is always deficient. Excess of proteid may also give rise to diarrhœa: though, at first, a tendency to constipation is more usual.

Constipation.—Constipation frequently occurs in the absence of sufficient fat in the diet. It may also arise from an excess of proteid. In other cases, alternations of diarrhœa and constipation are seen in connection with proteids either excessive in amount or of improper character. Disorders of this character frequently cause much

pain and disturbance. Signs and symptoms of this kind should never be regarded as trivial, and to be assuaged by the exhibition of some medicinal remedy; they require to be thoroughly investigated and promptly dealt with by appropriate dietetic adjustment.

Stomatitis.—Neglect of proper precautions is frequently followed by inflammation of the mucous membrane of the mouth. This may be of a catarrhal or ulcerative character, but by far the most common form is parasitic stomatitis (thrush), due to the fungus *Saccharomyces albicans*. This organism is widely distributed, but it does not develop upon healthy mucous membrane. Slight abrasions or a catarrhal condition of the mucous membrane are sufficient to permit of its development.

The appearance of thrush is characteristic. Small white flakes resembling fragments of curdled milk are distributed over the buccal mucous membrane, chiefly on the tongue and on the cheeks in line with the gums. Around these white spots are areolæ of inflamed mucous membrane, and when the flakes are forcibly removed there is generally a little bleeding from the denuded mucous membrane. If uninterfered with, the growth may extend so as to completely cover the mouth and pharynx. The mouth is dry, the tongue is furred, and the infant is generally suffering from gastro-intestinal indigestion.

If any doubt exists as to the nature of the condition, a fragment of the white masses should be placed on a slide and be moistened with a minim of liquor potassæ. In the case of thrush, on microscopical examination the fine threads (the mycelium) and small oval bodies (the spores), characteristic of the growth, will be readily detected.

The disease is always to be prevented by the systematic cleansing of the mouth after feeding, and by attention to the adequate cleansing of the nipples and everything coming in contact with the infant's mouth. A solution of boracic acid is the most useful for this purpose, but

care should be taken to see that all traces of this are removed from the nipple before suckling.

When the disease is present, the growths should be gently but thoroughly removed by a small swab of cotton-wool soaked in glycerinum boracis, and any further developments of the growth should be dealt with in the same way as soon as they appear.

Catarrhal stomatitis occurs occasionally in infants, and when severe is a distressing complication, making all attempts at feeding painful and difficult. In a well-marked case the vessels are dilated: the mucous membrane is very red and bleeds readily: the gums are much swollen and the mouth is hot. Saliva is freely poured out and is frequently present in extraordinary amount, so that it issues from the mouth in an almost continuous stream. The lips, chin, and cheeks may be much irritated, and, in consequence, become eczematous. The infant refuses food on account of the pain, and rapidly loses ground unless the condition is quickly dealt with.

In order to check the inflammation as soon as possible, the whole mouth should be swabbed with a pledget of cotton-wool which has been immersed in a 2 per cent. solution of silver nitrate, and from which all excess of the solution has been removed by pressure. The mouth should then be again swabbed with a solution of boracic acid. The skin in the neighbourhood of the mouth is best treated by being smeared with vaseline or oxide of zinc ointment, to prevent irritation from the saliva. Feeding should be carried out by means of a spoon, to save the infant the pain of suckling. If food is absolutely refused, the infant must be fed by means of the stomach-tube. On no account must the infant be allowed to be without its food by reason of the pain involved in feeding.

These severe cases are comparatively infrequent in the case of the young infant, and only occur when it has

been seriously neglected. Much milder forms are somewhat frequent, and they respond readily to suitable treatment.

The first dentition is an occasion when catarrhal stomatitis may appear; but the infant is older, the disorder is much less severe, and the general condition of the infant under these circumstances is very rarely at all serious.

Frequently associated with digestive disturbance is the rash popularly known as the 'gum rash.' *Lichen urticatus* is usually seen as raised hard papules with a somewhat translucent centre. The rash often gives rise to great irritation which calls for sedative applications, of which one of the best is liquor carbonis detergens in the proportion of one part to four parts of water. The rash is seen in many guises in different infants, but it should always be regarded as evidence that some dietetic error is present. It is of extremely frequent occurrence when cane-sugar or maltose is present. The severest forms are seen when the infant has been fed on an artificial food containing a large amount of maltose.

In the case of both the breast-fed and the substitute-fed infant some defect either in the character of the food or the method of its supply is the commonest cause of digestive disturbance, but this is by no means always the case.

The indefinite term 'chill' has a very definite application in the case of young infants. The relatively great body-surface necessarily leads to a comparatively excessive loss of heat. When this loss of heat is not counterbalanced by an equal creation of heat, the lower extremities, being furthest from the heart, are the first to suffer. Here the blood becomes cooled; the venous blood, thus cooled, returning through the vena cava, causes the temperature of the abdominal viscera to become subnormal.

This lowering of the animal heat normal to health is of serious import. As a rule, the intestinal symptoms are much more marked than the gastric. Pain, restlessness, green motions, and cold feet, are the cardinal signs of this condition. In these cases, the infant must be made thoroughly warm, and the intestinal catarrh generally soon subsides, if speedily treated, after a dose of castor-oil and the administration of bismuth for a day or two. Until the catarrh is at an end, the food should be dilute in fat and proteids; caseinogen should be present in not greater amount than 0·15 per cent. The whey proteids should constitute the greater part of the total proteid, which should not exceed 1 per cent., and in young infants may well be less than this. Two per cent. of fat is approximately the amount indicated for the condition.

Gastric and Intestinal Indigestion.—In the early months of life comparatively slight alterations, either in the quality or quantity of the food, may produce marked disturbance and suffering, so as to altogether interfere with the comfort and sleep of the infant. In this respect it need hardly be said that infants vary very much. An infant may be vigorous, healthy, and yet 'delicate.' Another infant, apparently not so vigorous nor so healthy in appearance, may show a much greater tolerance in regard to the digestion of its food.

Signs of Digestive Disorder.—The signs of indigestion in the infant are somewhat as follows. Soon after taking its meal, the infant shows signs of discomfort which are at first slight and gradually increase. It is restless, brings up gas from the stomach at intervals, cries almost incessantly, occasionally screaming violently and drawing up its legs as more severe spasms of pain occur. There is often a good deal of more or less persistent hiccough, with occasional eructations of sour food. In some cases actual vomiting occurs, with the ejection of large curdled masses.

In other cases the infant is more apathetic, cries scarcely at all, but looks ill. The face and lips twitch, the mouth is blue, and respiration is laboured. These signs are more frequently found in cases where atony and dilatation of the stomach have developed, so that the food lies as an inert mass in the stomach. As a rule, the infant is relieved by the expulsion of a large quantity of gas or by vomiting.

The intestines act irregularly: sometimes the motions are fairly normal, though never typically so; at other times they are grass green in colour, like chopped spinach, acid, acrid and offensive, and all gradations between the normal and the seriously abnormal are met with.

The infant suffering after every meal, unable to quietly sleep, soiling its clothes with regurgitated food, smelling sour, constantly fretful and crying, is a common clinical experience. Many more serious symptoms develop if the disorder is allowed to continue, but for a time the condition is apt to remain *in statu quo*.

The infant loses or does not gain in weight, or gains but slowly and irregularly. The ignorant nurse is content with calling it a 'sick baby,' and the anxious mother complains that the baby 'never seems really well.' In a great many cases all sorts of expedients have been resorted to, and nearly always the unfortunate infant has been dosed with drugs in which 'grey powder' or some such preparation largely figures. Little or no improvement has taken place, and those chiefly concerned have perhaps resigned themselves to the condition as one which apparently cannot be avoided. Yet there is no class of case which more quickly or more satisfactorily responds to really adequate management and treatment.

Treatment.—In the practical management the methods vary, to some extent, as to whether the infant is being fed by its mother or by substitution. The whole principle of the treatment consists in precisely adjusting the food to

the specific needs of the infant's digestion. Unless this can be attained, failure is inevitable.

In considering the immediate treatment advisable, it must be remembered that the digestive tract is greatly disordered, is filled with food materials in a state of noxious fermentation, and the number, character, and action of the micro-organisms present are altogether pathological. Under such conditions there is no milk mixture, however skilfully graduated, which will not undergo injurious changes. Hence the first indication is to get rid of the poisons and their products.

The author's usual practice is as follows, variations being made in accordance with the precise conditions of the individual case. The preliminary treatment should consist of lavage of the stomach, followed by an efficient dose of castor-oil to expel the intestinal contents. For a day or two after this it is usually advisable to give small but frequent doses of calomel, in order to prevent the recurrence of fermentation. This need not be continued for more than about forty-eight hours. The continuous use of drugs is seldom beneficial and frequently aggravates the condition.

Stomach Washing.—Various practical details in regard to washing out the stomach need some consideration. The apparatus required consists of a soft rubber catheter, in size from No. 8 to No. 10 (provided with a large eye), a glass funnel holding about 5 ounces, two rubber tubes connected by glass tubing, a jug holding about a quart and a basin in which to empty the washings.

Either a towel or a rubber sheet may be used to protect the infant from wetting. Plain boiled water may be used, but the addition of sodium bicarbonate (1 drachm to the pint) is useful, as this dissolves to some extent the mucus and allays irritation of the gastric mucous membrane. The temperature of the solution should be about 103° F., and not higher than 106° F.

The attempt to pass the tube when the infant is capable of struggling and wriggling into every conceivable position is not likely to be successful. The infant should be held in a sitting posture on the nurse's lap, and the operator should be seated immediately in front. All the nurse can do in the case of a vigorous infant is to restrain its body and limbs. The restraint of the head must be undertaken by someone standing behind the nurse, holding the head with one hand on each side. There must also be another assistant to pour the solution into the funnel as required.

In passing the tube, care must be taken that only the proper length is passed, else it will coil itself in the stomach; 10 inches from the gums is usually a sufficient length. The funnel should be raised as high as possible immediately the tube is passed, in order to allow of the escape of gas. It should then be lowered to the greatest extent possible to permit the exit of the stomach contents. This does not always occur, but it is greatly facilitated by a simple manœuvre. While the tube is held firmly at the mouth, without obliterating its calibre, by one hand, the external portion of the tube should be compressed by the finger and thumb of the other hand, sweeping towards the funnel.

From about 1 to 5 ounces of the fluid (according to the age of the infant) should then be gently poured into the funnel, and this is slowly raised till a free flow into the stomach takes place. As soon as the fluid has passed into the stomach, the funnel should be lowered and the washings siphoned into the basin. This procedure is repeated until the fluid returns quite clear.

At first, the washings are loaded with mucus and small curds. The large curds in the stomach are disintegrated by the repeated washings, so that the stomach is completely cleared of the fermenting mass. It is usually advisable to leave about 1 ounce of the solution in the

stomach. The infant should then be put to bed and kept warm. As a rule slight collapse follows the operation, but it is seldom severe and is speedily checked by a little brandy.

Food should be postponed for as long as possible in order to give the stomach rest. The first thing to be given is castor-oil, and after its administration a further period of at least two hours should be allowed to elapse.

In the case of the breast-fed infant, the mother's milk must not be allowed unless it is clear that this is not responsible for the illness. In the other cases temporary substitute feeding should be undertaken. The milk mixture provided should be of a delicate character, containing very little caseinogen and rather more alkaline than usual. For an infant eight weeks old the following prescription is likely to prove suitable:

℞	Per Cent.
Fat - - - - -	2·00
Lactose - - - -	6·00
Whey proteids - -	0·50
Caseinogen - - -	0·15
Alkalinity - - -	10·00

Unheated. Nine feedings, each containing 2½ ounces.

When the mixture agrees with the infant, the constituents should be gradually increased in amount, especial care, however, being exercised in regard to the caseinogen.

Before the second feed is administered the dose of calomel should be given, and the further doses at the prescribed intervals.

The Character of the Mother's Milk.—In reference to digestive disorder in the infant fed by its mother, nothing is more important than that the precise character of the milk supplied to the infant should be known. A sample of milk should be obtained by means of the breast-pump under strict precautions, and the specimen should be analyzed. The fact that the mother is herself well and that she is supplying a sufficient amount of milk must

not be regarded as rendering this examination unnecessary. In some cases several analyses may be necessary. It is sometimes found that the milk of the mother varies greatly, occasionally agreeing with the infant, sometimes causing the greatest disturbance. These variations almost always correspond with the habits of the mother. The following summary of a case illustrates some of the important factors:

The milk in the middle of the second week was analyzed, and found to contain:

	Per Cent.
Fat - - - - -	3·25
Lactose - - - -	6·50
Proteids - - - -	1·60

At this time the infant was doing well, and the analysis was made in accordance with the author's usual practice in the management of lactation.

At the end of the third week the mother had a violent dispute with one of her servants in the temporary absence of the nurse, and, being of a nervous temperament, was greatly upset. The next day the infant was suffering severely from colic. The motions were green, and there was considerable regurgitation of sour curds. The analysis of the milk showed a profound alteration in its character:

	Per Cent.
Fat - - - - -	1·25
Lactose - - - -	6·00
Proteids - - - -	4·50

As soon as the symptoms in the infant showed themselves, it was removed from the breast and placed on a substitute food corresponding to the normal milk of the mother. The mother was then treated by diet, exercise, etc., and a further analysis at the end of a week demonstrated that her milk was of a suitable character. The infant was again breast-fed, and did well. On one or two later occasions some difficulty was experienced, as the mother was apt to excite herself unduly; but the disturbances were of a temporary character and the infant was fed by its mother until it was weaned at the end of the sixth month.

The characters of the disorders arising in breast feeding have been previously discussed in reference to the management of lactation.

Zymotic Enteritis (Acute Gastro-Enteritis, Epidemic Diarrhœa, Cholera Infantum).—In the terrible mortality of young infant life, the disease known chiefly by its most prominent symptom—diarrhœa—is the commonest factor, being found to account for one-third of the total deaths under one year of age.

It is usually seen in the form of an epidemic, and is closely associated with the prevalence of hot and especially dry weather. The epidemic form usually begins in June, and increases in severity till the height is reached in July, when it begins to diminish, and practically ceases in October. In consequence of this almost constant limitation to a certain part of the year, the temperature or the 'season' has been regarded as an essential factor in the causation of the disease. This view, however, is not a tenable one. The disease is almost entirely confined to bottle-fed infants, and the incidence of the epidemic is determined by the favourable or unfavourable conditions present in regard to the development of bacteria.

In the poorer classes, the overcrowding, inadequate ventilation, and the many defects in hygiene and sanitation, probably play some part in the havoc wrought by an epidemic; but sanitary defects *per se* are not the cause. In almost all cases, it is only when these defects result in the contamination of the infant's food that the disease arises.

Symptoms of Zymotic Enteritis.—The symptoms of the disease vary according to the character and acuteness of the attack, and all gradations may be met with in practice. These variations depend on the twofold factor of the degree of resistance possessed by the infant, and the degree of virulence of the infection.

As a rule, symptoms of indigestion of the kind previously described have been present for some time, so that predisposition to the severer form of infection is present.

In mild cases, the onset is gradual, being accompanied by fever of a moderate degree, and gastric disturbance is

not a marked feature. The diarrhœa develops gradually; the motions become more frequent, and their colour changes from yellow to green, becoming watery, acid, and offensive, and containing masses of undigested food.

The infant is pallid, very weak, apathetic, and moans. The weight decreases. These cases of gradual onset with comparatively moderate symptoms are the most hopeful of the epidemic form when treated with the necessary care and attention.

The most acute cases present a very different clinical picture. An infant previously healthy and gaining well in weight suddenly becomes ill. The skin is hot, the temperature rises rapidly, and the infant shows all the signs of severe distress: it draws up its legs, moves restlessly, and continuously writhes with pain; sleep is almost entirely absent. Vomiting is generally the first sign, and it is extremely severe; at first it vomits food, and then retching sets in. No food can be retained by the stomach, even water in some cases being immediately vomited. Diarrhœa then ensues, after an interval of twelve hours, more or less, from the initial illness. The onset of the diarrhœa is marked by the frequent expulsion of flatus, while the motions are of the character above described. Within twenty-four hours they greatly increase in frequency; the intestines act every hour or even more frequently, the discharge becomes entirely fluid, almost colourless, and is sometimes very offensive, at other times almost without odour. The amount of fluid thus lost may be enormous, and the infant visibly shrinks.

Many writers have endeavoured to classify the disease, so as to represent the various gradations of severity, but no definite or essential clinical distinctions exist, since the precise virulence of infection and the power of resistance vary in each case. A feeble infant may rapidly succumb to an infection, the effects of which are resisted by another infant with comparative ease.

In some cases, the diarrhœa continues for about a week. The infant is exceedingly ill, but at the end of this period distinct improvement begins, and, in a short time, it is out of danger. On the other hand, the infant may die within a few hours or a few days. In other cases, the symptoms become obstinately chronic, with alternations of improvement and relapse, till the infant dies from exhaustion, presenting a pitiable spectacle of exhaustion and wasting.

The signs in a severe case are striking. The pulse is very weak, rapid, and sometimes uncountable. The crying, so prominent in the earlier part of the attack, ceases, and is replaced by a feeble moan. The cheeks sink inwards, and the redundant skin falls into many folds; the eyes recede, leaving a space between the lids and the eye itself. The eyes and mouth remain open during sleep, owing to the loss of tonic muscular contraction.

In consequence of the extreme loss of fluid from the system, the infant seems to shrink within itself; the fontanelles are depressed, the subcutaneous fat disappears, and, as the disease progresses, the infant presents a ghastly spectacle. The temperature, at first high, becomes subnormal, the extremities are cold and clammy, the pulse is scarcely to be felt. Thrush invades the mouth, the buttocks become eczematous, and the infant passes from a condition of stupor into one of profound collapse and death. In some cases, however, though death seems imminent and treatment fails to gain any response, the infant lingers in a semi-conscious condition, till hypostatic pulmonary congestion or some other complication occurs. In cases as grave as this life may sometimes be saved if the treatment be prompt and thorough. In the worst cases, which have become well established before they are seen, the most skilful treatment, as a rule, fails to gain the smallest response.

When recovery has been established for some time, the diarrhœa has ceased or is much less, and food is being taken, a relapse may occur with death in a few hours, or heart failure may occur, giving rise to sudden death. In the author's experience of these grave forms, convulsions are never seen.

The acuteness of the disease, and the terrible mortality associated with it, in spite of the most skilful treatment, lead us at once to look rather to the prevention of the disease than to its medical treatment.

Among the poor, where the epidemics are so frequent, the prevention of overcrowding, the provision of hygienic surroundings, the insuring of plenty of fresh air and sun in the rooms, the provision of parks and open spaces, all play an important part in combating the inroads of pathogenic micro-organisms. In the hygiene of the young infant, the greatest care must be taken in reference to the soiled napkins and to all sanitary rules. Under the present conditions, organized assistance in the shape of well-trained district nurses would probably be of great value in aiding mothers to observe the necessary precautions and in pointing out defects.

The insanitary surroundings find by far their greatest practical expression in virtue of the resulting infection of the food taken by the bottle-fed baby. And where the infants are fed on artificial foods all the conditions for an epidemic of the most severe and fatal character are present. By the use of these artificial foods the resisting power of the infant is almost completely destroyed. Probably some gastro-enteric disturbance of a minor character has been already in existence for a considerable time. The combination of these factors with an epidemic explains the excessive mortality.

In Chapter XVII. the incidence of infantile mortality and disease and the methods of prevention are described.

Treatment of Zymotic Enteritis.—In the treatment

of zymotic enteritis, the first essential is to remove as speedily and as thoroughly as possible from the stomach and the whole of the intestinal tract the poisonous products formed by the pathogenic micro-organisms, together with the bacteria themselves. The stomach should be thoroughly washed out and the colon irrigated.

Irrigation of the Colon.—Irrigation of the colon is carried out as follows: The apparatus consists of a douche can capable of holding a quart, rubber tubing and a rectal tube. The fluid should be normal saline solution, and its temperature 100° F.

It is important that the buttocks should be elevated, so as to encourage the flow of the fluid into the colon. This is best effected by laying the infant on a table and bringing the buttocks, elevated by pillows, to the edge.

In order to prevent injurious hydrostatic pressure, the douche can should be very gently raised, and the elevation should not be greater than necessary to permit of a gentle flow of the solution into the colon. No attempt should be made to pass the tube past the rectum until the fluid flows readily; as soon as this occurs, the tube should be passed into the colon to the extent of about 12 inches from the anus. Without the previous distension by the flowing fluid, the tube almost invariably doubles upon itself in the rectum.

The length and shape of the sigmoid flexure render it necessary that the tube should be passed slowly, in order to allow of its adaptation to the curves. It is not necessary that the tube should be introduced further than the termination of the descending colon. If this is accomplished, the whole colon from the cæcum downwards is flushed out; if not, only the sigmoid flexure or rectum is reached. This limited irrigation is of little avail.

In infants of six months of age and older, at least a pint may be introduced before any of the solution returns. When this amount is retained, it is an indication that the

solution has reached the colon. As the solution continues to pass, from time to time gushes of fluid issue from the rectum; but the irrigation should not be discontinued until the washings return quite clear. When this is accomplished, the tubing should be disconnected from the rectal tube, and this should be left in the colon for a time, in order to allow of the escape of any fluid that has been retained. In from half an hour to two hours this fluid will have been voided and the tube may then be removed.

As a rule, not less than 4 pints of the solution should be used and frequently this amount may be doubled with advantage, the test being the condition of the returning fluid. During the early part of the procedure, gentle massage or kneading of the abdomen facilitates the passage of the fluid into the colon.

Stomach-washing is generally only required once, and seldom more than twice. In the case of colon irrigation, however, so long as the action of pathogenic bacteria persists, it is good practice to repeat the irrigation every twenty-four hours, until the indications for its use have ceased. In cases of urgency, where the symptoms of intestinal poisoning are acute and extreme, the irrigation may be required two or three times in the first twenty-four hours. In these cases, and in others where collapse and prostration are marked, the temperature of the fluid may be raised with good effect to 105° F., or somewhat higher; it should not, however, exceed 110° F.

Thus, by purely physical means, a large and important part of the alimentary tract may be treated with results much more satisfactory than could be attained by drugs. Moreover, evacuation of the colon almost invariably results in a greatly-increased peristaltic activity of the small intestine, and thus further facilitates the elimination of the poisons.

As soon as this preliminary treatment has been accom-

plished, certain drugs may with great advantage be administered; but so numerous are the medicaments recommended for infantile diarrhœa, and so useless or pernicious are the great majority of them, that it is necessary to determine the specific object to be attained, and how far any proposed remedy is likely to assist its accomplishment.

If vomiting has ceased, castor-oil should be administered. For an infant of three months of age 1 drachm should be given, as soon as possible, to be followed by another drachm in an hour's time. This seems to give better results than giving 2 drachms at once. In the matter of the dose of castor-oil, it is usually well to err rather on the side of slight excess.

Following the castor-oil, calomel ($\frac{1}{8}$ grain) should be given every hour for six doses. In the author's experience, this method is by far the most reliable and satisfactory method of treatment by drugs. Calomel seems to act specifically in promoting intestinal disinfection in a way that none of the much-vaunted intestinal antiseptics can approach. Indeed, the great majority of them, when administered, seem rather to complicate the disease than to alleviate it. Salol is to some extent an exception. It cannot be compared with calomel for prompt disinfection; but, in the more chronic cases of intestinal decomposition, it is sometimes beneficial.

From the beginning, in a case that threatens to be serious, alcohol is indicated. For an infant three months of age, 5 minims of Cognac brandy in a drachm of water should be given every hour. Champagne in small amounts may be very useful.

Every effort should be made to keep the infant warm. So long as the infant is warm, its powers of reaction and recovery have their greatest chance; once it begins to grow cold, its chances rapidly diminish. A hot mustard bath is both warming and stimulating, and may be of

great service. In these cases, during the acute symptoms, the condition of the alimentary tract renders the absorption or digestion of food out of the question, and it is worse than useless to attempt to give that which increases the irritation, and, if it is not rejected by the stomach, provides material upon which the pathogenic organisms may flourish.

Boiled water should be supplied freely; it serves to diminish the thirst caused by the frequent intestinal evacuations. To it may be added lactose, the strength being about 5 per cent., when this does not cause irritation of the stomach. Lactose to some extent maintains the energy and resistance of the infant.

In those cases where the intestinal drain is great and the signs of exhaustion and collapse previously described are beginning, subcutaneous injections of normal saline solution should be freely used. The axillæ, the buttocks, and the abdominal wall are favourable sites for the injections.

Subcutaneous feeding by ox serum, lactose in 5 per cent. solution, and by olive-oil, has been recommended. Of these, oil is the most efficient in providing for nutrition: 30 to 40 cubic centimetres of previously sterilized olive-oil may be injected into the buttocks slowly with a large syringe. The usefulness of these measures is very limited. It is not the loss of food but the loss of fluid, which, next to the toxæmia, gives rise to the urgent symptoms. This can be most satisfactorily dealt with by subcutaneous injections of normal saline solution. Of the beneficial results from this method there can be no doubt. It should, however, be injected in comparatively small amounts (from 4 to 6 ounces) at frequent intervals. This gives much better results than one injection of a large amount.

As soon as the stomach and intestines have been thoroughly cleansed of the poisons, *rest* is the most im-

portant factor in the treatment. Opium, in minute doses, is, in the author's opinion, of the greatest value. Tinctura camphoræ composita in 2-minim doses every hour may be administered, the case being carefully watched. Where opium appears to be contra-indicated, the following mixture may be used:

℞
Acid. carbolic. liq.	-	♏ ii.
Ol. menth. pip.	- -	♏ i.
Sp. chloroform.	- -	♏ x.
Aquam	- -	ad ℥i.

1 drachm to be given every hour.

The sub-nitrate of bismuth is also useful in allaying the intestinal irritation. The effect of opium upon infants has been unduly exaggerated. In anything approaching the doses normal for the adult it is, of course, highly dangerous; but, in minute doses, it is extremely valuable, especially in cases of severe gastro-enteritis, after the physical evacuation of the poisonous materials. It gives the infant the rest it so much needs, acts, as a rule powerfully, in checking the intestinal irritation and stimulates the heart and respiration.

When it appears advisable to give food, the greatest care must be taken that only the lightest and most absorbable food be given. Milk must be altogether withheld at first. Albumin-water, whey (whole or diluted with water), chicken broth, panopepton, are all useful. In all cases some lactose should be given; this is, of course, present in whey, and when other fluids are given it should be added. Without it the normal action of the lactic bacilli cannot be regained. The feedings should be extremely small in amount, and at frequent intervals. The return to milk should be very gradual. Fat may first be added in small proportion (1 per cent.); then the lactose may be raised in amount. The proportion of caseinogen should be severely limited until the infant has quite recovered.

CHAPTER XIV

INANITION—MALNUTRITION—MARASMUS

THE class of case to be dealt with in this chapter is frequently met with, but our present knowledge does not permit of accurate classification. Certain of the most marked forms of marasmic disease may arise from specific causes which have not yet been determined.

In regard to the precise pathology of marasmus various views have been formulated. Baginsky stated that the defect was one of absorption and that the amount of nitrogenous material absorbed was much lessened, being as much as 50 per cent. less than the average amount. This was attributed by him to atrophy of the intestinal mucous membrane. These views have been contested by various observers, and the failure of nitrogenous absorption has not been confirmed. Heubner attributed the disease to a toxæmia arising from intestinal decomposition, and this view, with various modifications, is the one commonly held at the present time.

Ruhrah[1] has recently brought forward some observations with the view of showing that the disease is primarily connected with atrophy of the thymus gland. Eighteen cases were reported upon. The atrophy of the thymus gland was the only constant lesion found in any of the necropsies. The average weight of the gland was

[1] 'The Relation of the Thymus Gland to Marasmus' (*British Medical Journal*, August 29, 1903).

3·41 grammes, whereas the normal weight of the gland at birth is 12 grammes.

There can be little question that the thymus gland forms to some extent an index of nutrition and that changes occur in its structure in correspondence with the degree of malnutrition. No evidence, however, has yet been brought forward to show that these changes play any direct part in the causation of the disease. Administration of the dried thymus gland is not productive of any benefit in cases of marasmus. On the other hand, some of the worst cases of marasmus may make a complete recovery by treatment of the intestinal condition and adjustment of the diet.

As malnutrition is a relative term, it must always be that some cases do not fall into any definite group. Under this name, indeed, may be included all diseases due to dietetic error, such, for instance, as rachitis and scorbutus. But since these forms present signs and symptoms characteristic of themselves, the general term is usually reserved for those forms of defective nutrition not characterized by localized lesions.

In the case of complete starvation acute inanition develops. Where the starvation is relative as, for instance, where the food supplied has been of considerable amount but of improper character, the atrophy is more gradual, and the general condition known as malnutrition develops. While when the defective nutrition becomes so marked that the digestive and absorptive functions of the alimentary canal are almost completely in abeyance, the condition becomes one of marasmus. It is hardly necessary to say that a precise division between these forms is impossible; nevertheless, a marked case of marasmus is peculiarly characteristic.

Acute Inanition.—Acute inanition develops suddenly. The temperature is generally subnormal, but may be raised; the pulse is extremely weak; the loss of weight is extra-

ordinarily rapid. A deathly pallor is the striking feature in the appearance, and all the signs of collapse are present in varying degree. Extreme muscular weakness is a prominent symptom. Diarrhœa is acute and obstinate, so that food passes rapidly through the alimentary canal almost unchanged.

The prognosis in these cases is extremely grave. The essential feature of cases that have reached this stage lies in the almost complete destruction of the assimilative functions. The most hopeful measures to be adopted are the subcutaneous injection of saline solution, and of brandy.

Very small doses of opium are sometimes extremely valuable. It checks the active metabolism and seems to be the means of giving rest to and invigorating the organism, so that after its administration the infant gradually improves and is able to absorb a small amount of nutriment.

It is important that food should be administered with great caution. If it passes through the infant rapidly and sets up diarrhœa, it is doing harm. Until the gastric and intestinal condition responsible for this has been to some extent ameliorated, the administration of food by the mouth only aggravates the severity of the case, and prejudices the chance of recovery. Sterilized water should be given by the mouth as freely as circumstances permit. When it is judged that the time has come to attempt feeding, the most easily absorbed food in very small quantity should be given. Panopepton suitably diluted or peptonized whey are useful, and the amount given at one time should not exceed one teaspoonful. Unless the infant is kept warm, it will almost certainly die.

In cases where the infants survive the acute stage, progress is remarkably rapid, and rapid changes in the character of the substitute feeding are necessary in order to meet the demands of the organism for food. Sudden

15

and disappointing relapses are, however, apt to occur, and no prognosis with regard to recovery should be given until the infant has made steady progress for at least a month. Great care must be taken to insure that the digestion is not suddenly overtaxed.

A sudden increase of 1 per cent. in the fat of the food mixture may result in diarrhœa and in an acute relapse. If progress is being made, no attempt should be made to alter the proportions of the constituents for at least a week, and the increase should be fractional—not more than 0·15 per cent. of any constituent at any one time. In all cases the fat and proteid content must be kept much below the normal standard for a considerable period. Lactose, as a rule, appears to be more easily tolerated, though this should not exceed 6 per cent.

General Malnutrition.—General malnutrition is the commonest pathological feature of infant life. Probably 50 per cent. of all infants in this country suffer from a greater or less degree, and this large proportion is caused undoubtedly by the extremely unsatisfactory methods of substitute feeding at present in vogue. Illness, in the usually accepted sense of the word, is not present. No specific disease can be diagnosed, and unless the indications are realized the degeneration is allowed to proceed until marasmus or some acute disorder supervenes. The gain in weight is slow and much below normal; or, as in some cases where glucose and maltose have formed the most prominent part of the diet, the weight may be even greater than usual. The growth of the trunk and the development of the chest and head are retarded, and the general impairment of health may be associated with specific expression in the shape of hydrocephalus, rachitis, or other disease.

The general appearance of an infant suffering from malnutrition is very typical. There is a lack of brightness in the eyes, the face is pallid and worn-looking;

it is very weak, and seems 'poorly' and miserable. Among the poorer classes the treatment of the condition is almost hopeless, unless the parents are assisted so that they may obtain the appropriate food, and are able to secure for the infant fresh pure air with plenty of sunlight.

In almost all cases the symptoms of gastro-intestinal derangement are well marked, and it is consequently almost impossible to obtain any satisfactory results while the infants are treated as 'out-patients.' On the other hand, a comparatively short course of adequate treatment, followed by a stay in the country, with a continuance of proper food and care, is attended with the most favourable results.

It is astonishing how frequently such cases are met with in private practice in the homes of those well able to provide everything requisite for the health of the infant. The general ignorance of the community and the want of adequate knowledge on the part of some members of the medical profession are the two most prominent factors responsible for this. Cases are constantly met with where the first principles concerned with the nutrition of the infant have been ignored under circumstances rendering the neglect almost inexplicable.

Another factor of great practical importance is the nurse or nursemaid. The danger here is often great and is frequently extremely difficult of detection. For a long time certain 'nurses' associated with infants have been accustomed to hold their own opinions on the subject of 'the baby,' and to carry them out not only without the knowledge of the medical attendant, but without informing the mother or anyone else.

It is always advisable to impress the mother with the importance of herself supervising the feeding and care of the infant, so that she is in a position to speak precisely, and from her own observation, as to what the baby has

or has not received. If an ignorant and obstinate nurse is allowed to tamper with the infant's digestion, it is obvious that the most exact procedures may altogether fail.

In some instances where the ill-health of the infant has continued despite all efforts, a change of the nurse has been attended with striking benefit. Several such cases have occurred in the author's experience. In one striking instance it was afterwards discovered that the nurse had been giving the infant some preparation which she had been in the habit of using in India, and whence she brought it. The precise character of this was never discovered, but, from the infant's symptoms, it in all probability contained opium, or some product with similar properties. In this case, the improvement of the infant's condition was distinctly recognisable in less than forty-eight hours from her departure. For more than a week prior to the nurse's discharge the author had intimated his suspicions, but had, unfortunately, yielded to the urgent representations of the mother that they were without foundation. In other cases the nurse is found to be using 'magnesia,' 'dill-water,' and powders or mixtures of various sorts. These possibilities need to be borne in mind.

Marasmus.—Marasmus represents the extreme result of gradual and long-continued malnutrition. Extreme wasting is the cardinal, and indeed only, specific symptom. The term is not applicable to those cases where the wasting is the result of exhaustion due to the incidence of specific disease, such, for instance, as tuberculosis.

The subcutaneous fat almost completely disappears, so that the skin becomes, relatively, altogether redundant, and the face of the infant is like to that of a wizened old man. The skin is dry, heavily wrinkled, of a dirty, sallow colour, and hangs in folds around the bony structures. The infant presents a most pitiable spectacle.

The signs are those associated with extreme weakness, and need not be specifically recapitulated. As a rule the temperature is subnormal. In some cases the appetite is very poor; in others it is ravenous. In some the food is scarcely at all digested; in others it seems to be well digested and the motions are normal. These latter are attended with the worst prognosis, since the absence of serious digestive disturbance is an indication that the changes in the organism are of a more profound character and have almost passed beyond the scope of treatment. The following case illustrates the chief features of marasmus:

J. B., first seen at the age of eight and a half months. For about the first fortnight of life it had been nursed by its mother, but her milk failed and it was then fed on condensed milk which, from the account, was much diluted. As this did not agree with the infant, it was then fed with a patent food for infants, and for some time 'did well.' At a later period, the infant had bronchitis and seemed very 'out of sorts' after this, so that it did not take its food well, and many kinds of artificial foods were tried. It was then again given condensed milk and was being fed on this when seen. The weight at birth could not be obtained, but it was described as big and healthy.

The weight was 6¼ pounds, and the infant presented the most extreme signs of emaciation. It was extremely apathetic, and, indeed, barely conscious. It could not raise its limbs from the bed, or even maintain them raised when they were lifted. The breathing was so feeble that the respiratory movements were almost imperceptible; the pulse was very weak, but was fairly regular at a rate of about 140 per minute. The temperature per rectum was 97·2°.

The motions were semi-solid, and in appearance somewhat like clay. The following is a summary of the chief points in the treatment and further history of the case:

The infant was swathed in cotton-wool, 6 ounces of normal saline solution at 100° F. were injected into the right axilla, and 5 minims of brandy in a teaspoonful of warm water were administered by the mouth every hour. The following mixture was ordered, 1 ounce to be given every hour:

℞	Per Cent.
Fat - - - - -	1·00
Lactose - - - -	6·00
Proteids - - - -	0·75
Lime-water - - -	10·00

Peptonized.

In two days the infant's condition was better, and its appearance had distinctly improved, but its weight had not increased. Daily inunctions with cod-liver-oil were then carried out, and the infant was fed every hour with a peptonized mixture of the following composition:

℞	Per Cent.
Fat - - - - -	1·00
Lactose - - - -	6·00
Proteids - - - -	1·00
Lime-water - - -	5·00

At the end of a further seven days the progress was noticeable. The weight had increased by 2 ounces, and the apathy and weakness were much less. The oil inunctions were continued, and the composition of the food was maintained, but the amount was increased to 2 ounces every two hours. During the next ten days progress was uninterrupted, and the food was then altered so as to be of the same percentage composition as before, but only half of it was peptonized. In a few days from this change, the mixture was given entirely without peptonization.

It then steadily progressed until an attempt was made to increase the fat percentage to 1·50, when somewhat severe diarrhœa ensued and the infant lost ground. In about a week it was again progressing, but it was not found possible to increase the constituents of the food till six weeks after the beginning of treatment, and during this period relapses were of occasional recurrence. At the end of this period the infant began to visibly change; its appetite became almost ravenous, so that it soon required 6 ounces at each feed, with an interval of three hours. In correspondence with this increase in the amount, the fat required to be rapidly increased, and at the ninth week of treatment it was taking and digesting well a mixture according to the following prescription:

℞	Per Cent.
Fat - - - - -	3·75
Lactose - - - -	7·00
Proteids - - - -	1·50
Lime-water - - -	5·00

Eight feedings, each containing 7 ounces.

The gain in weight was now regular, and at twelve months of age the infant was sent to the country weighing 11½ pounds. The first

tooth appeared at thirteen months. The gain in weight and the general progress were extremely satisfactory, and at eighteen months of age the weight was 18¾ pounds.

The above case affords an extremely satisfactory instance of the effects of careful treatment by dietetic adjustment. It must, however, be admitted that such a result is far from being always obtained. Despite the greatest care, severe cases of marasmus are often extremely difficult to treat, and a high mortality is necessarily associated with the disease in its severe form. This undoubtedly arises from the severe injury to the structures chiefly concerned with digestion and absorption. One of the most discouraging features in the bad cases is the disappointing relapses which are apt to occur after most hopeful progress has been made. These relapses seldom, if ever, occur without some cause, but the factor determining them may be so slight that the relapses may easily be regarded as quite spontaneous.

The slightest overfeeding, the insufficient warming of a single feed, a very slight alteration in the character of the food, and many other slight deviations from the normal, may provoke vomiting or diarrhœa. When this occurs the infant loses ground at once, the symptoms only slowly abate, and it is probably a week or more before the infant ceases to lose weight and begins to again make progress. This tendency to relapse is illustrated in the following case:

F. M., first seen at the age of five and a half months. The previous history was very indefinite, as it had been put out to nurse. It was stated to have been quite healthy at birth. Its present weight was 6 pounds 14 ounces, and it presented the typical signs of marasmus. It was placed on a food according to the following prescription:

℞	Per Cent.
Fat	1·00
Lactose	6·00
Whey proteids	0·50
Caseinogen	0·15
Alkalinity	5·00

Eight feedings, each containing 3 ounces.

The food was taken well, and the amount had to be increased. At the end of a week it was taking 6 ounces, each feed being of the following composition :

℞	Per Cent.
Fat	1·00
Lactose	6·50
Whey proteids	0·75
Caseinogen	0·25
Alkalinity	5·00

For the first fortnight the infant did well, its weight rising to 7 pounds 11 ounces. At the end of this period it was sick after one of its feeds, green and offensive motions appeared, and despite the utmost care, both in regard to nursing and in regard to the diet, it steadily lost weight during the next week, till it reached 6 pounds 11 ounces, 3 ounces below its weight when first seen. Thus, in seven days it had lost 16 ounces in weight. It now again made progress, and had almost made up its lost weight, when a slight relapse again occurred, and the weight fell to 6 pounds 15 ounces. From this time its progress was almost continuous, though very slow at times, and at the age of eight months its weight was 9¼ pounds and the infant was making satisfactory progress.

In another case, very similar to the one above described, the infant made good progress for a fortnight, when a relapse occurred and death ensued in forty-eight hours from the onset of symptoms.

These cases therefore require the most extreme care, and need to be protected from every prejudicial influence in the most complete manner possible. In all cases of marasmus the prognosis should be guarded until the disease has practically disappeared and the infant's progress has been satisfactory and continuous.

CHAPTER XV

RACHITIS

THE most striking and perhaps the commonest result of impaired nutrition is the disease generally known by the name of rickets. Though some of its most obvious features are those associated with changes in the osseous system, these are by no means the only effects of the disease. Rachitis is the expression of profound pathological changes occurring in practically all the tissues of the body.

No other disease illustrates so completely the effects of inadequate nutrition. An infant nursed by its mother and receiving from her a sufficient supply of adequate food never contracts the disease, however disadvantageous its environment may be in other respects.

Defect in the diet is the prime and essential cause of rachitis; while, as might be expected, the most advanced forms of the disease are to be seen when the effects of inadequate food are intensified by unhygienic environment.

When the disease is adequately treated at an early stage by the correction of dietetic error, the cure is often rapid and complete. In other cases, where the disease has become well established and the deformity of bone well marked, a real cure is seldom if ever to be attained, though some of the grosser deformities may be, to a certain extent, corrected by surgical operation.

The effects of rachitis on the general constitution are extremely severe. The relationship between the nutrition of the infant and the condition of the child and adult has received but little attention. But there can be no doubt that the defects of nutrition occurring in infancy are of paramount importance in regard to the development of the adult. The cases of retarded physical and mental development in the child and adult are numerous at the present time, and it is probable that their chief cause lies in defective nutrition during the period of infancy.

Incidence. — Rachitis is seldom found in breast-fed infants, and the great majority of cases occur among those that are hand-fed. When it arises in a breast-fed infant, it is due to the inadequacy of the milk supplied by the mother, coupled as a rule with extremely unhealthy environment. Holt points out that in New York it is common, in the case of Italian children, to see marked rickets in those entirely breast-fed. When lactation is prolonged beyond its normal limits, and the infant receives no other, or inadequate, food in addition, the disease may arise.

Etiology —The primary cause of rachitis is the absence of the necessary food elements in the diet of the infant. Bland-Sutton's observations in the Zoological Gardens fully support the conclusions derived from clinical observation in this respect. Lion whelps weaned early and fed solely upon raw meat invariably became extremely rachitic, and the disease was so marked that it was impossible to rear them. Two young bears fed entirely upon rice, biscuits and raw meat developed extreme rachitis and died. Two young monkeys upon an exclusively vegetable diet became rachitic. In the case of the young lions, the hygienic conditions and all the other factors of the environment remained the same, but the food was changed to one consisting of meat, milk, cod-liver-oil, and pounded

bones. In three months all signs of rachitis had disappeared.

Effects of Diet.—In regard to the precise elements of the diet the absence of which tends to produce rickets there can now be little question. At one time, it was widely thought that absence of a sufficient quantity of lime was the cause. This is altogether opposed to the facts. Infants who have received a plenitude of lime, as in the case of substitute-fed infants in limestone districts, are by no means protected from rickets. The artificial foods which play the greatest part in the incidence of rachitis usually contain both calcium and phosphoric acid in large quantities.

Deficiency of fat is the most important factor. Deficiency of proteid, alone, seldom if ever causes rickets, but when the two are both deficient the disease is much aggravated. This is the explanation of the fact that rickets is so especially liable to occur in hand-fed infants, and occurs most frequently in those fed on artificial foods. Fat is (next to lactose) present in human milk in greater amount than any other of the solid constituents. The artificial foods are characterized, as has already been shown, by the great deficiency or practical absence of this element. Structural development is retarded by the absence of a due amount of proteids of the proper character, and deficiency of the normal albuminoids is a great factor in intensifying the occurrence and severity of the disease.

Contributory Causes.—While dietetic error is the prime etiological factor, other factors play a very great part in determining the precise incidence of the disease, the degree of its development, and its effects upon the tissues. Of these contributory causes, defective hygiene is the most prominent. The presence of constitutional disease, such as syphilis, diminishes the resistance of the infant and allows the disease wider scope. Digestive disorders seldom give rise to rickets when the food has been

at all adequate. Holt refers to the fact that acute diseases of the stomach and intestine are frequently followed by marasmus, but only exceptionally by rachitis.

Impure air, the absence of sunlight and invigorating atmosphere, are the common incidents of the crowded homes and tenements of the poor classes in the towns. To the infant the plentiful supply of pure fresh air and sunlight are almost as important as its food. Hence the worst cases of rickets are almost always found in the large towns.

The provision of open spaces, of public parks where infants may obtain as far as possible these elements so essential to their health, is of great practical importance in its relation to the vigour and physique of the population.

Age of Incidence.—The disease is seldom seen before the sixth month or after the third year, while between the tenth and the twentieth months of life most cases occur. Gee[1] analyzed 635 cases in reference to the age of the patients. From twelve to eighteen months there were 183 cases, from six to twelve months 144, from eighteen months to two years 133. Thirty-two cases were seen under six months, and 27 cases were seen in the fourth year. The disease is commonly seen towards the end of the first year, is most frequent in the earlier months of the second year, and seldom occurs after the infant is three years old.

Pathological Changes.—The lesions of rachitis are widespread. They are most manifest in the bones, but also implicate the brain, liver, spleen, muscles and, indeed, every organ may be affected to a greater or less extent. The changes in the bones represent a wide deviation from the normal conditions. In the long bones the production of cartilage at the epiphysis is exaggerated, while, along the shaft, there is excessive cellular develop-

[1] 'St. Bartholomew's Hospital Reports,' vol. iv., p. 69.

ment beneath the periosteum. The normal formation of the medullary canal by absorption of the inner layers is generally exaggerated, so that the medulla may be much wider than usual.

Morbid Anatomy.—On examining a longitudinal section of a long bone, the lower end is seen to be much enlarged, and the cartilaginous layer between the shaft and the epiphysis is both wider and deeper. This enlarged area constitutes the *blue zone*, and is in marked contrast with the conditions of normal epiphyseal development. A thin regular line normally represents the bone-forming cartilage, whereas in rickets it forms a large and irregular mass. The centres of ossification are soft, swollen and exceptionally vascular; they are surrounded by a mass of degenerate tissue. The outer layers of the diaphyses are thickened and soft; towards the medulla the bone is firmer, and the internal layers are more or less completely ossified. The medulla is hyperæmic, and the medullary contents consist of a soft pink mass somewhat resembling pulpy granulation tissue.[1]

Microscopical Appearances.—Microscopical examination demonstrates the precise nature of these gross changes. In the areas of developing bone are masses of imperfectly ossified tissue interspersed between areas chiefly composed of proliferating enlarged cartilage cells. From the periosteum and medulla are projected masses of similar character, so that the whole bone is composed of osteoid rather than of osseous tissue.

[1] *Vide* Bollinger's 'Pathological Anatomy,' part ii., plate xl., for graphic illustrations of rachitis of the lower end of the femur, and rachitis of a rib. See also illustrations in Ashby and Wright's 'Diseases of Children': (1) Section through lower end of rachitic radius, showing exaggerated depth and irregular borders of the proliferating epiphyseal cartilage; (2) transverse section through the shaft of the ulna from a rachitic infant of thirteen months, showing spongy tissue beneath the periosteum instead of the compact tissue of normal bone.

The absorption of calcareous material around the cartilage cells is carried out more or less normally, but the next stage, the formation of bone, is very imperfect. The normal bone is replaced by degenerate cartilaginous and osseous tissue.

After a space of time, varying between six and eighteen months, these degenerative changes cease, and a partial restoration of comparatively normal tissue begins. The cartilaginous masses gradually become hard, and in many cases much harder and denser than normal bone, so as to resemble ivory. The epiphyseal enlargements diminish in size, so that in slight cases the lesions may be obliterated. In advanced cases the results are seen in the shape of numerous deformities.

Onset of the Disease.—The onset of rachitis is insidious. Many cases are at first regarded as instances of general malnutrition, and their nature is not detected until, as the disease progresses, the more obvious signs manifest themselves. It is important that the cases should be treated as early as possible, in order to prevent degeneration of the tissues.

Clinical Features.—Two symptoms are of nearly constant occurrence, and usually appear much earlier than any others—excessive perspiration and restlessness, which are much more marked at night than in the daytime.

The sweating is profuse, so that the head is wet. Upon the forehead large beads of sweat form, and run down over the face. When the infant sleeps the perspiration is extreme. The whole head, face and neck are bathed in moisture, so much so that the pillow is often thoroughly wet and the infant is awakened by reason of its discomfort. The bloodvessels in these cases are usually full, both the veins and arteries being distended. As a result of the excessive sweating, and the consequent irritation, a rash often appears around the hair follicles and on the forehead and neck.

This rachitic sweating is remarkable, as the sweat glands in the rest of the body are not affected to anything approaching the same degree. The skin of the trunk and extremities is often abnormally dry. Of the precise cause of this peculiar symptom little is known, but the remarkable localization points to a disorder of the nervous system. Profuse general sweating is a sign of weakness and exhaustion, and is in the adult frequently observed in the convalescence from disease, notably from typhoid fever.

The discomfort and restlessness at night are often very marked. The infant throws itself spasmodically from side to side, sometimes lying on its back, sometimes on its face, and changing its position frequently and with great suddenness, as if it had been pushed. While these constant movements are made the infant is not awake, but sleeps on in a disturbed slumber.

Intolerance of the bedclothes is a frequent accompaniment of the restlessness. Regardless of the temperature of the room, the infant will rid itself of all its coverings, kicking away the clothes and lying almost naked on the bed.

Constipation is a very common feature and occurs at an early period, though it is usually more marked in the later stages. In many cases, alternations of constipation and moderate diarrhœa are seen. The motions are offensive and frequently contain a large amount of undigested food. In moderately advanced cases of the disease the albuminoid constituents are only very partially assimilated, so that putrefactive changes occur in the intestine. The symptoms of intestinal indigestion are generally present in these instances.

It must be remembered that rachitis frequently occurs in infants who appear upon superficial observation to be well and flourishing. They are often quite plump, and no suspicion of serious disease is entertained by the

mother. The author has seen a considerable number of infants, put forward as fine specimens of babyhood, who on examination proved to be the subjects of rachitis, either definitely established or plainly threatening.

As the disease progresses and the malnutrition becomes more extreme, emaciation almost always occurs; but in the earlier stages this loss of flesh is unusual, and the presence of a normal or an abnormal amount of adipose tissue should not be allowed to influence the diagnosis. Excess of fat and lack of muscular tone are, perhaps, the commonest characteristics of early rachitis as presented in infants fed on artificial foods containing a very small quantity of fat and a great excess of carbohydrate.

As a rule, the infant suffers from thirst, and the demand for food seems sometimes to be insatiable, so that soon after feeding the infant is not satisfied until it is fed again. This symptom is probably the result of the systemic need for essential constituents either partially or entirely absent in its diet, and is analogous to the marked predilection shown by scorbutic infants for a diet in which the antiscorbutic elements are freely present.

Frequently a rachitic infant does not come under observation until the disease has been established for some time and the more profound changes have occurred. In a well-marked case the signs are numerous and extremely characteristic.

The head is large, the chest is narrow, the ribs are 'beaded,' and, at the wrists and ankles, the epiphyses are greatly enlarged. The abdomen is distended and the limbs are curved.

The changes in the bones are widely distributed, and, with the exception of the bones of the skull, are always of the same character, the enlargement occurring at the junction of the bone and the epiphyseal cartilage.

The Skull.—The size of the head is out of proportion to the size of the infant and the enlargement is due to thickening of the cranial bones and to abnormalities of development. Marked thickening of the frontal and parietal eminences occurs, so that the intervening sagittal, frontal, and coronal sutures appear to be depressed. The vertex is flattened and the antero-posterior diameter of the skull is increased.

In consequence of the exaggerated depresssion of the coronal suture, the thickening of the frontal bones and the general flatness of the vertex, the forehead is projected forwards, is of abnormal depth and square-shaped. This large forehead often appears to be larger than it really is, owing to the shape of the head and the contrast with the bones of the face, the growth of which is arrested.

The sutures are as a rule open, and ossification is delayed. The anterior fontanelle, which ought to be practically closed at the end of the first year, may be widely open. The occiput is flattened and the occipital bone, in contrast with the others, is often much thinned. In some cases the osseous tissue is so deficient that in localized spots the bone is almost as thin as paper, and yields readily to pressure. These spots are always of small size, being either quite minute or about the size of the tip of the little finger. This condition, known as *craniotabes*, is a remarkable feature peculiar to the bones of the skull. It is probably the result of pressure on the ill-nourished bone, from the infant lying with the back of the head on the pillow. In most of these cases the hair in the occipital region is worn away as a result of this pressure and the frequent and restless movement of the infant during sleep.

The thickening of the bones and the shape of the head are modified under treatment, but in advanced cases some malformation of the head persists throughout life, so that the effects of rachitis in early life may be seen in the

16

adult. The shape of the adult head is notably influenced by the incidence of rachitis in infancy. It is much more noticeable, as a rule, in men, as in women the arrangement of the hair greatly obscures the outlines.

The Thorax.—In the chest, one of the earliest and most striking of the bone changes is seen in the 'beading' of the ribs. At the junction of the rib and the costal cartilage a nodule is formed; the character of this is precisely the same as the epiphyseal enlargements already described in reference to the long bones. These nodules are readily felt on palpation of the chest, but the greater part of the nodule is usually situated on the internal aspect of the chest wall, so that their full extent is to be more clearly realized in the post-mortem room.

Beading of the ribs is an extremely uniform sign, and does not occur in any other disease. Out of 144 successive cases of rachitis examined by Holt, 142 were found to have this sign at the time of the first examination.

Other changes occur in the thorax, due to the softening of the bones and the consequent yielding to atmospheric pressure. The transverse diameter is diminished, and the antero-posterior diameter is increased. At the antero-lateral aspect of the chest on each side is a deep longitudinal depression, extending from the second to the ninth rib, the depression being greatest just external to the junction of the rib and the cartilages. The yielding of the chest wall in this situation leads to the protrusion of the sternum and the costal cartilages, the whole forming the condition known as 'pigeon-breast.'

At the lower part of the chest, extending transversely across it, and corresponding to the line of the diaphragm, a deep furrow, about 2 inches in breadth, is formed which is known as Harrison's sulcus. In some cases a deep depression is found in the region of the ensiform cartilage, producing the deformity known as the 'funnel chest.'

The Spine.—Deformity of the spine is quite common,

but it is only in the most advanced cases that this is due to serious alterations in the structure of the vertebræ. The most common deformity is that of kyphosis, which generally arises from the weakness of the muscles and ligaments, and disappears when the infant is suspended or the extremities are extended. In bad cases, however, the vertebræ may be affected, and the deformity is not to be corrected by manipulation. Scoliosis and lordosis may also be met with, but are not nearly so frequent as kyphosis. As a rule, the backward curve is not sharp, as in angular curvature, but is gradual. It begins in the dorsal region, is most prominent in the dorso-lumbar and gradually disappears in the lower lumbar region.

The Clavicle.—The clavicle is, as a rule, not greatly affected, except in severe cases. The disease shows itself in an enlargement of the curve in its inner third, and in thickening of the epiphyses. Occasionally the bone is incompletely fractured ('green stick fracture').

The Extremities.—In the upper extremity the most frequent abnormality is the enlargement of the epiphyses. This occurs most commonly at the wrist and is one of the typical signs being nearly always present. It may also be present at the elbow.

Both the radius and ulnar are commonly affected, becoming much curved, the convexity of the curve being on the extensor aspect. Incomplete fracture of these bones is of common occurrence and almost invariably occurs on the concave side of the curvature.

In the lower extremity, the enlargement at the ankles is generally found to correspond with that at the wrists, though, as a rule, it is not so well marked. In advanced cases the upper epiphyses of the tibia and fibula are affected. Both these bones may be much bent, the tibia usually being the more severely affected. The femur may show some curvature forwards and outwards, and its condyles are enlarged.

When the disease has progressed the deformities of bow-legs and knock-knees are seen, but these do not usually manifest themselves till infancy is passed.

The Pelvis.—The pelvis in severe cases may be extremely distorted, and in the female adult this is of serious moment in reference to obstetrical considerations. With the exception of the pelvis of mollities ossium and some other rare forms, rachitis is responsible for the worst cases of pelvic contraction. In regard to the number of cases, this disease is overwhelmingly in preponderance.

Holt refers to an important fact which has received little attention. The growth of the long bones is arrested. This is one of the most characteristic features, so much so that a rachitic child of three years often measures, in height, 6 or 8 inches less than a healthy child of the same age, the difference being almost entirely in the lower extremities. The arrest of growth is also seen in the bones of the face, especially the upper jaw and the malar bones. The lower jaw alters in shape, so that, anteriorly, it is flattened, and the angle is much more acute than is normally the case.

The bone changes in rickets are therefore of wide extent and affect the whole skeleton. Attention is naturally drawn to these features, since they present such obvious abnormalities as to be quite apparent to the untrained observer. The changes affecting the other tissues are no less severe, but the fact and character of these lesions are not so clearly recognisable.

The Muscles and Ligaments.—The muscles are very poorly developed, so that their power is much less than normal and in some cases is almost absent. The inability of infants to maintain themselves in an erect posture, to sit up, or to walk, is not so much due to the bone changes as to the absence of muscular strength.

The ligaments and especially those structures of a ligamento-muscular type connected with the important

joints, with the spinal column and with the neck, are relaxed and atonic. The ligamental laxity and the muscular weakness give rise to a flail-like mobility of the limbs which is in marked contrast to the normal muscular tone and posture.

Of this atonic condition a notable example is the extreme distension of the abdomen which is so frequently present. The muscles of the abdominal wall and of the intestines are relaxed, with the result of extensive dilatation of the whole intestinal tract. The abdomen is tympanitic and tense.

When the disease has reached a marked stage, the features of marasmus are added. The facial expression becomes senile and the infant is apathetic. Respiration is laboured and quick, owing to the weakness of the respiratory muscles and the thoracic deformities.

There is usually some tenderness in the neighbourhood of the joints when the disease is active, but it is never acute and is frequently absent. The acute tenderness such as is found in scorbutus is never present in an uncomplicated case of rachitis.

In a disease associated with so many complications, febrile symptoms frequently appear and disappear; but *pyrexia* is not an essential sign of rachitis, and the most acute rachitic changes develop without fever.

During the most progressive stage enlargement of the spleen almost invariably occurs, but this seldom persists and is never very great. Enlargement of the liver also occurs, though the increase is not as great as that occurring in the spleen, and it is not so frequent. An important point in determining the size of the liver and spleen should always receive due recognition. Owing to the deformities of the thorax, both these organs are pushed downwards, so that they become more prominently abdominal organs; and in the estimation of the size of these organs the part played by this downward displacement must be allowed for.

Dentition.—The process of dentition is generally delayed and may be complicated by severe nervous or intestinal symptoms. In some cases the first teeth appear at about the normal time, while the appearance of the others is irregular and delayed. Dental caries is a common incident.

Ultimate Effects of Rachitis.—Rachitis is a disease attended with a high mortality with which it is never credited, for the disease itself is seldom, if ever, fatal. In consequence of the cachectic condition and the extreme debility associated with advanced rachitis, the specific infectious diseases, such as measles, pertussis, and others, are associated with a much higher mortality in these cases than in others. Associated more or less closely with rachitis is a large class of disorders, such as bronchitis, diarrhœa, laryngismus stridulus, convulsions; these are attended with many fatal issues.

The figures given by Gee[1] support this statement. Out of 50 cases of laryngismus stridulus, 48 were rachitic, and of these 19 had convulsions. Of 102 cases of general convulsions, 46 were rachitic.

Even in later life the effects of rachitis seem unquestionable. Gowers found that 10 per cent. of epileptics had suffered from rachitis. Coutts found the rachitic history more frequent and assessed it at 17 per cent.

These degenerations of the nervous system must be a prominent factor in the want of resistance to disease, while in the cases of the numerous lung complications the effects are greatly enhanced by the chest deformities already referred to.

Treatment.—The active stage of rachitis is of comparatively limited duration. Treatment begun late in the second year must be of little avail, for probably by this time irremediable mischief has been done. At the twentieth month of life the active disease is rarely seen.

[1] 'St. Bartholomew's Hospital Reports,' vol. iii.

At about this time the cessation of the disease almost always occurs, owing to the changes in the diet and environment. Hence diagnosis and treatment should be especially devoted to the recognition and correction of the defects when the bone changes are not present, or are so comparatively slight that they can only be detected on careful examination. In such cases due adjustment of the diet and environment is attended with most satisfactory results.

Under the present conditions, the majority of cases are not presented for treatment until the disease has been in existence for a considerable period and where its results are apparent on the most superficial examination.

In the treatment of these cases, drugs are often temporarily required for the various intestinal, nervous, and other complications. But in regard to the disease itself drugs are of no avail. Phosphorus, iron, arsenic, may be of use in regard to certain of the incidents of rachitis, but they are useless in regard to the specific disease. The various preparations containing lime salts, advocated from theoretical considerations based on the deficiency of lime in rachitic bone, are quite useless.

The two factors of the utmost importance are the diet and the character of the environment in regard to hygienic conditions. Deficiency of fat is the prime cause of the disease, and, clinically, all observers are agreed upon the extremely beneficial effects of cod-liver-oil.

It should be given as freely as possible, regard being had to the state of the digestion. The oil may also be used as an inunction. This is a valuable method in bad cases of rickets, as in other wasting diseases. After a warm bath the skin is quickly dried, and a tablespoonful of the oil is rubbed with the palm of the hand into the skin of the abdomen, or into the groins or the axillæ.

Cream is still better than cod-liver-oil for administration by the mouth. The amount of fat can be regulated

by prescribing cream of definite percentage. In infants presenting only the premonitory symptoms, a milk mixture containing a high percentage of fat, with the other constituents in normal proportion, provides all that is required in regard to diet. In the more advanced cases occurring at a later age—that is, about the end of the first year—cod-liver-oil, cream, and raw-meat juice are the most important foods, the rest of the diet being such as is generally suitable for the age.

Fresh air and plenty of sunlight are essential. Whenever it is possible, the infant should be in a climate mild and warm, so that the infant can be out of doors for a great part of the day. The bracing and more vigorous climates are scarcely suitable, as these patients are extremely susceptible to cold. Later, when the infant has become more vigorous and its powers of resistance have increased, a more bracing air is of great advantage.

As a result of the disease, gastric and intestinal disorders are usually present, and these require careful treatment in order to enable the infant to assimilate the full diet necessary to recovery. Generally there is some diarrhœa, the motions being offensive, more or less green in colour, and frequently mucus is present. In order to clean the alimentary tract as thoroughly as possible, castor-oil followed by a few doses of calomel is of great value as a preliminary treatment.

Care must also be exercised in not too rapidly placing the infant upon its full diet. Especially in young infants should caution be used in regard to the proteids, so that the proportion of caseinogen is relatively small in amount. Generally, in regard to the digestive disorders present, the correction of these requires that the management and treatment should be carried out on the principles previously discussed. Where diarrhœa still continues, carbonate of bismuth may be given in fairly large doses. Opium should very rarely be used. Starchy food may be found

to form a large part of the dietary, and this should be reduced to the lowest possible limit.

When the infant has recovered from alimentary disorders, it may be placed on a more varied diet. But while disorder is present it is of the greatest importance that the primal proximate principles should be made use of to the exclusion of more complex foods. By this restriction of the diet it is possible to control the nutrition and to know the facts of the case in a manner that is impossible when the diet is composed of a large variety of foods.

Hygienic Management.—Especial care must be taken to insure that the body-heat is maintained. The loss of animal heat, which has been referred to previously, is one of the greatest factors in regard to the health of the infant, and one which is very widely neglected. In order to reserve as much of the fat as possible for direct nutrition, it is important that this energy should not be wasted in correcting excessive loss of heat.

The abdomen should be protected by a closely-fitting flannel bandage, which serves to keep the infant warm, and, at the same time, to provide the support which a rachitic infant generally requires.

The living and sleeping rooms should be maintained at an equable temperature of 63° F., and the ventilation should be so arranged as to provide for the ingress of plenty of pure air and the egress of impure air without draughts.

It is frequently found that ventilation is deficient owing to the absence of sufficient provision for the regular egress of impure air; without this the air of the room must necessarily be impure.

The extremities need to be protected so that these are warm. 'Cold feet' are found here as in other conditions, and the feet and legs should therefore be well protected by means of stockings.

Special provisions need to be made to counteract the disturbance of the bed-clothes and the exposure of the infant resulting from its restlessness at night. The infant should be placed in a flannel sack tied just below the shoulders; over this a flannel nightgown with long sleeves should be worn, buttoning at the wrists and neck, and lightly fastened to the sack at the feet. In this way the infant may be securely protected. Weighty bed-clothes are especially resented by the rachitic infant, and the bed-clothes should be warm but light, the greater reliance being placed on the night garments of the kind described.

The attendants of the infant should always be cautioned in regard to the condition of the bed-clothing and the night garments. They must be dry. This object is often difficult of attainment without constant care, in consequence of the copious sweating, so that the ordinary 'airing' of the clothing is not sufficient. They require in these cases to be dried by direct heat.

Treatment of Complications.—For the profuse sweating of the head and neck, belladonna or its alkaloid, atropine, may be given. Three minims of tinctura belladonnæ should be given in the afternoon, and 5 minims on the infant being put to bed; or $\frac{1}{600}$ grain of atropine may be given in the afternoon, and $\frac{1}{400}$ grain at bedtime—these doses for an infant of six months.

Infants are sometimes extremely tolerant of belladonna, and it may be necessary to increase the dose. This should be done with caution, as in some cases the usual tolerance is not shown. Alcohol is, in the author's experience, a valuable agent in producing a more restful sleep and in allaying, to a great extent, the excessive sweating. A small quantity of champagne with 3 or 5 minims of spiritus chloroformi given in the evening is often remarkably effective.

Bronchial catarrh is liable to appear and, if neglected, is prone to end in broncho-pneumonia, which is always

a serious complication in consequence of the thoracic deformities.

On the occurrence of symptoms of bronchitis, the infant should be given a hot bath, and after rapid drying with warm towels the chest should be well rubbed with a liniment, such as the linimentum camphoræ ammoniatum; this acts as a stimulant, and its inhaled vapour incites the expulsion of mucous exudation.

Chloretone inhalant provides a valuable means of checking the extension of catarrh. This preparation consists of a mixture of chloretone, camphor, menthol, and oil of cinnamon, mixed with a basis of petroleum. It should be sprayed into the throat by means of an atomiser.

When the symptoms are severe, and dyspnœic distress is evident, vinum ipecacuanhæ should be given to produce vomiting, and thus assist the expulsion of the mucous secretion blocking the bronchial tubes.

Unless the mucous secretion is freely evacuated, its interference with respiration is severe. Antimony is a valuable drug in these cases, and may be given as in the following prescription for an infant of six months of age:

℞

Vini antimonialis Vini ipecacuanhæ	āā ♏iii.
Liq. ammon. acet.	♏x.
Aquam	ad ℥i.

In all such cases, alcohol in the form of brandy is of great value.

The affections of the nervous system in the shape of laryngismus stridulus and of convulsions are frequent complications. An infant suffering from convulsions should be placed in a hot bath (from 100° F. to 105° F.), and amyl nitrite should be given as an inhalation. After a considerable experience with chloroform and other drugs, the author has found amyl nitrite the most satisfactory. In most cases the convulsions cease almost immediately after its inhalation.

To prevent the recurrence of convulsions, bromide of potassium should be given. The first dose should consist of 2 grains, and this should be followed by 1 grain every hour for the following six hours. In cases where convulsions recur, opium or morphia is the most efficient means of combating the attacks.

Numerous observers with great experience are agreed that the tolerance of morphia in cases of convulsions is well marked, and a weak action of the heart is not a contra-indication to its use. 'Objections are urged against it only by those who have had no experience with its use' (Holt). For an infant of six months old, $\frac{1}{50}$ grain should be injected hypodermically. Or, instead of the hypodermic injection of morphine, 4 grains of chloral hydrate may be administered per rectum for an infant of the same age. But morphia is more certain. In some cases the administration of oxygen is attended with beneficial results.

Laryngismus stridulus is an alarming complication, and in some cases it may be quickly fatal. In the majority of cases, however, the first attacks are comparatively mild, and the attacks gradually increase in severity. When the nature of the attacks is diagnosed at an early stage and the case is suitably treated a fatal result is very rare.

The onset is sudden; the head is thrown back; the face becomes at first pale, then deeply cyanosed; respiration ceases. For a few moments the infant is in the greatest distress; the cyanosis deepens, till the infant is almost black and violent, but abortive attempts at respiration are made. After this condition has lasted for some seconds, the spasm ceases and a peculiarly long and deep inspiration follows. As a rule, the incidence of the attack is determined by some excitement—by crying or by a fit of anger.

The face should be sprinkled with cold water and the tongue should be drawn well forward, and smelling-salts

should be held at the nostrils. As a rule this rapidly ends the spasm. When, however, the attacks recur at frequent intervals, chloroform should be administered. The infant should then be kept very quiet, should not be disturbed by visitors, and potassium bromide may be given with advantage for a few days.

The presence of digestive disorder, of constipation, of scybalous masses in the rectum, are some of the frequent and immediate associations of laryngismus, and these conditions need to be dealt with. In some cases local diseases of the air-passages may either be the cause or the aggravation of the disorder. Of these adenoid vegetations and hypertrophy of the tonsils or uvula are instances.

In regard to the nervous system, the best results will be obtained by adequate diet. The improvement in the functions of the nervous system as a result of suitable food is most striking and is often to be seen in less than a week from the beginning of treatment.

CHAPTER XVI

SCORBUTUS

Scorbutus, as it occurs in infants, is characterized by its dependence on imperfect nutrition. The disease is almost entirely confined to a certain period of infancy. It rarely arises before six months or after eighteen months of age, and is most commonly seen in the latter half of the first year, especially during the eighth, ninth, and tenth months. In rare cases, however, it may be found much earlier, and Holt refers to cases in which the disease has been observed in infants less than one month old.

In a mild form it characteristically occurs in infants who have not suffered previously from any serious disease, and who have been under the most favourable conditions in regard to general care and environment.

The disease as seen in infants was first described by Cheadle in 1878.[1] Prior to this, Smith had in 1876 described a case, but its nature had not been recognised.[2] Gee in 1881 included a series of cases of the same disease in an article entitled 'Osteal or Periosteal Cachexia.'[3] In 1883 Barlow[4] demonstrated the clinical and pathological

[1] 'Three Cases of Scurvy supervening on Rickets in Young Children.

[2] 'Hæmorrhagic Periostitis . . . with Separation of the Epiphyses ('Transactions Pathological Society, London,' vol. xxvii.).

[3] 'St. Bartholomew's Hospital Reports,' 1881.

[4] 'On Cases described as Acute Rickets . . .' ('Transactions Royal Medico-Chirurgical Soc.,' vol. lxvi.).

character of the disease. The conclusions at which he arrived have been fully confirmed by later observations.

Etiology.—Practically all observers are agreed that the disease is entirely due to defective diet, though the precise nature of the defect has never yet been fully demonstrated. Certain facts, however, are clearly established. So long as the food is fresh it never produces scurvy. Fresh food possesses some property—the antiscorbutic property—which is destroyed at a high temperature.

Some writers have suggested that the disease is due to a micro-organism—a suggestion which is, however, based on little, if any, evidence. The theory of bacterial etiology as the primary element is highly improbable by reason both of the incidence of the disease and its disappearance.

Gee[1] inclines to the view that the disease is due to a poison of the nature of a ptomaine, though admitting that nothing is certain in regard to this.

The evidence that scorbutus is primarily due to the *absence* of some necessary element, and not to the presence of any poisonous products, is extremely strong; though it may be that these products arise as a result of the defective metabolism. These, however, must be regarded as effect rather than cause. The facts of the disease all point in this direction.

The infants are generally healthy in other respects and the disease is gradual in its onset—both of which facts are against its association with ptomaine-poisoning as this term is usually understood. And, despite the maintenance of the same diet, the disease is to be cured provided that the antiscorbutic element be added in sufficient amount.

Moreover, food that produces scorbutus only produces it when this diet is either the sole diet or is so much in excess that the other food is practically negligible. Condensed milk never produces scorbutus when it is only part

[1] *St. Bartholomew's Hospital Journal*, June, 1903.

of the dietary, and the other food is antiscorbutic in character and is sufficiently plentiful.

The valuable investigations of the American Pediatric Society carried out in 1898 afford the most complete illustration of the subject. The records of cases were collected and the statistics in relation to the diet leave no room for doubt as to the essential cause of scorbutus. The figures are as follows:

PREVIOUS DIET OF INFANTS SUFFERING FROM SCORBUTUS.

Breast milk was accountable for - - -	10	cases.
Breast milk with additional food was accountable for - - - - - - -	2	"
Raw cow's milk was accountable for - -	5	"
Pasteurized cow's milk was accountable for	20	"
Condensed cow's milk was accountable for	60	"
Sterilized cow's milk was accountable for -	107	"
Proprietary foods were accountable for - -	214	"

In reference to those cases occurring in breast-fed infants, no case appears to have ever been recorded where the milk, as judged by the progress of the infant and by analysis, has been at all of normal standard. It is probable that, not only were the milks altogether abnormal, but that all the mothers were in a state of comparative starvation. In regard to this, it is noteworthy that on raw cow's milk only five cases are recorded. In the chapter dealing with the effects of heat on milk, the important factors have already been discussed and it is only necessary here to draw attention to the striking demonstration of the part played by condensed milk, sterilized milk, and proprietary infant foods. Speaking of condensed milk and of other artificial foods in relation to scorbutus, Gee says: 'These foods came in about the year 1870. I was then at the Children's Hospital, and previous to that time I had never seen a case. When I first saw it and described it, I thought it a new disease.'

Pathological Changes.—The pathological changes in advanced scorbutus are characteristic. Hæmorrhage into the tissues is the prominent lesion. It may be found in the muscles, in the tissues, in the neighbourhood of the joints, and occasionally, though rarely, in the joints themselves. Hæmorrhages of variable extent occur in the serous cavities such as the pleura and pericardium, and into organs such as the liver and spleen. But by far the most constant and most striking feature of advanced scorbutus is subperiosteal hæmorrhage. This is chiefly found in connection with the long bones, and most markedly in connection with those of the lower extremities.

In advanced cases the bone itself is also involved, and separation of the epiphyses is not uncommon, especially at the knee-joint. Hæmorrhages into the mucous surfaces are very common, the gums being specially affected.

Clinical Features.—The symptoms of scorbutus in an advanced case are characteristic. The limbs are extremely tender; the infant cannot bear to be touched and screams or shrieks at the slightest pressure on the long bones.

In the early period of the disease the soreness is indefinite, but when scorbutus is established this symptom cannot be missed, for the mother, nurse, and all concerned are struck by it. Its earliest manifestation is usually in connection with the knees and ankles, or the immediate neighbourhood of these joints.

The gums are not, as a rule, affected unless teeth have appeared. As, however, the disease does not usually appear till dentition has occurred, the gums are affected in most cases. They are greatly swollen, sometimes to an extraordinary degree, so as to completely obliterate the natural outlines; they are of a purple colour, spongy in texture and bleed on the slightest friction or spontaneously. The greatest swelling is found in the middle of the upper jaw in the region of the central incisor, and the teeth may be obliterated from view.

The infant is pallid and cachetic and the tissues are easily bruised. The limbs, especially the legs, are swollen, owing to subperiosteal hæmorrhage. The posture of the infant is suggestive. It lies in its cot looking very helpless and sad, its legs are kept quite motionless, and almost every voluntary movement is avoided, on account of the pain involved. Occasionally, in the worst cases, this apparent paralysis is due to separation of the epiphyses.

Anæmia is always present, and sleep is fitful and disturbed, sometimes being almost absent. The urine may contain albumin.

Hæmaturia may be a prominent symptom. In certain cases the signs and symptoms above described may be very slightly marked, and blood in the urine forms the only prominent feature. This is of comparative rarity, but it should be remembered that of infantile hæmaturia scorbutus is probably the commonest cause.

A case was recently seen which illustrates this point. An infant, twelve months old, had suffered for about six weeks from intermittent hæmaturia. It was anæmic, pallid and fretful. The limbs were not swollen, but the left femur was tender on moderate pressure. The gums were rather dark in colour, but were not swollen, nor did they bleed. The food of the infant had been consistently heated to boiling-point or thereabouts.

Both the usual medical attendant and a surgeon had been at pains to establish the cause of the condition, and the question of a calculus had been discussed. As the condition appeared to be due to scorbutus, the infant was ordered fresh milk, raw-meat juice and orange juice. The recovery was rapid. The hæmaturia entirely ceased in ten days, and the infant made very satisfactory progress in health and weight.

Treatment.—The treatment of scorbutus is essentially dietetic. The food must be fresh and unheated. But as milk is of comparatively weak antiscorbutic power, the disappearance of the disease is slow unless the products most powerful in this direction are added to the diet.

The juice of fresh ripe fruit appears to possess the antiscorbutic property in the highest degree. As a rule, the

juice of oranges or lemons is generally available, and but little difficulty is experienced in inducing the infant to take any desired quantity. Indeed, it is remarkable that the physiological need seems to be illustrated by the appetite, for it is very noticeable that scorbutic infants usually take these juices with eagerness and relish.

For an infant of six months, the juice of two or three oranges or lemons may be given each day. Other fruits are useful, such as grapes, greengages, plums, apples and pears. All possess the required property, and it is sometimes advantageous to change the precise kind of fruit used in the diet. Care is necessary to insure that no part of the fruit is decomposed and that the juice is carefully strained, so that none of the solid constituents are given.

An objection to the use of fruit-juice is sometimes raised on the ground that it is liable to incite diarrhœa and otherwise disturb the digestion. This may be the more feared, as in most cases digestive disorder is already present. These considerations should not be allowed to hinder the free supply of the materials essential to cure. The digestive disorders rapidly disappear in correspondence with the other scorbutic symptoms.

Raw-meat juice is a valuable agent. In addition to providing the necessary element of fresh food, it assists in the cure of the anæmia and of the cachectic condition.

While the cure of the specific condition of scorbutus is readily obtained in most cases by the regulation of the diet on the principles above described, the infant is often somewhat feeble and delicate for a considerable period following the disappearance of the scorbutic symptoms. The general condition at the termination of the acute symptoms requires careful management. As a rule, the digestion is weak, the circulation is feeble, the blood is greatly deficient in hæmoglobin and the nervous system is unstable. These conditions must be met by careful adjustment of the diet. Raw-meat juice is extremely

useful at this stage, and the milk mixture should contain as high a proportion of fat as can be tolerated by the infant's digestion.

Cases of advanced scorbutus are comparatively rare, but cases showing the earlier signs are quite common. In these latter cases the tenderness is not acute, but is sufficiently marked to prevent the infant from moving its limbs at all freely. This symptom is very commonly seen and has been described as 'pseudo-paralysis.' The following case illustrates the general features of a case of early scorbutus, and the importance of realizing their meaning:

A. G., a female infant, aged nine months. The author was asked to see this infant as the parents were much alarmed in regard to its condition. For some little time it had been ailing, was not sleeping well and symptoms of gastric and intestinal indigestion had gradually increased. The infant was under the best possible circumstances as regards care and attention, and the nurse was extremely conscientious and anxious about the baby. Latterly the parents and the nurse had been much alarmed, as the infant did not move its legs or feet. Its right foot was kept quite motionless. The appetite was poor, and the infant suffered from flatulence. The motions were green and curdled. It had been seen by a physician, who had given a very guarded prognosis and had evidently regarded the cause as primarily connected with the nervous system. No sign of subperiosteal or other hæmorrhages could be found, nor could any history of superficial hæmorrhage be elicited. At the base of the teeth was a purplish margin, not raised above the surface, not spongy, but sufficiently distinct as to be definitely outlined from the adjacent tissues. The infant showed none of the signs of acute tenderness; it permitted gentle manipulation of the legs without protest; but on the right leg being gently gripped it cried somewhat feebly, whereas it made so sign when the left leg was grasped with considerable force. The motionlessness and flaccidity of the lower extremities, the purplish margin around the base of the teeth, the slight but definite tenderness of the right leg, together with certain gastro-intestinal symptoms and the general appearance of the infant, led the author to make the diagnosis of scorbutus. Forty-eight hours after this diagnosis had been made, bleeding from the gums occurred.

The recent diet had consisted of milk mixtures, to which had some-

times been added Imperial Granum and sometimes Mellin's Food; the food had invariably been raised to the boiling-point in the course of its preparation.

The infant was placed on a modified milk unheated, and was given the juice of two oranges daily. After a few days, in which the digestive disorder gave rise to some trouble, the infant made rapid progress, and in less than three weeks had made a complete recovery.

This case is noteworthy because the symptoms of localized tenderness were not marked. On the other hand, the lower limbs were so atonic as to suggest some organic lesion of the muscles or nerves. Hence this condition is likely to lead to serious error in the diagnosis and prognosis of the case. It is necessary, therefore, to bear in mind the fact that this pseudo-paralysis is a feature which is very commonly seen in scorbutus and is uncommon in other diseases.

It is also well to bear in mind that infants often suffer from the deficiency of the antiscorbutic element in their food without presenting any symptom sufficiently typical to justify the diagnosis of scorbutus. These cases are generally found when the greater part of the food has been heated, so that the necessary element, though not altogether absent, is markedly deficient. Lack of appetite, indigestion, alternation of restlessness with languor, are the symptoms which the nurse sums up by saying that the baby seems 'very poorly.' Such symptoms as these are, of course, not limited to scorbutus, but they are suggestive. In such cases the only feature at all characteristic is the cry, which is of a whimpering, unhappy character and is seldom vigorous. It is not altogether unlike the cry of marasmus, but is distinguished by the fact that early scorbutus is generally found to occur in infants presenting superficially the appearances of being well nourished. When the condition rapidly yields to fresh unheated food and orange or lemon juice, the cause is clear; it can seldom be definitely diagnosed until

the experiment has been tried. These cases, which may be termed *scorbutoid*, are extremely common and their cause is far from being generally appreciated.

In contrast with the above instances, one case may be cited illustrating the severity of the disease when fully developed :

A male infant, aged twelve and a half months, was first seen by the writer in April, 1903. It was stated to have been a fine, healthy child at birth ; no reliable evidence as to its birth weight could be obtained. For the first two months it was nursed by its mother ; after this it was fed on one of the preparations known as humanized milk. As this did not agree with the infant, a patent food was then used, and as the infant continued to be unwell various forms of patent preparations were resorted to. The mother stated that at the age of six months it seemed to be making progress, at eight months it seemed again to be ill, and from this time its condition altered very much, the infant sometimes seeming to be well, at other times being 'very poorly indeed.' In the last six weeks it had become very much worse.

The infant lay in its bed extremely apathetic and barely conscious. Its face was ashy gray in colour, the respirations were extremely frequent, the pulse-rate was 144 per minute, and the temperature was 103·2°. When touched it moaned feebly, and made no attempt at movement. The mouth was kept open, the lower jaw hanging away from the face. There was a complete absence of muscular tone, so that the infant appeared to be quite incapable of voluntary movement.

The mouth presented a horrible appearance. No sign of the teeth could be discovered, though it was stated that several had appeared. All that could be seen was a purple mass, which was so extensive that on superficial inspection it was difficult to distinguish between the upper and lower jaws, despite their wide separation. Scattered over this purple mass were areas of necrosing tissue, the odour of which was extremely unpleasant.

Petechial hæmorrhages were distributed over the back and limbs, and a large patch of extravasated blood was found in the region of the left hip.

Tenderness, manifested by moaning and by the facial expression, was present in all the limbs.

There was a general enlargement over both humeri throughout their length ; the ulna and radius did not appear to be thus affected, but the index-finger of the right hand was enlarged, especially at the junction

of the metatarsal bone with the first phalanx, the enlargement being at each side of the joint.

In the legs the signs were extreme. At both knee-joints the skin was tightly stretched over the swollen epiphyses; the tenderness also was greater than at any other part.

Bleeding from the gums and nose had occurred; no history of hæmaturia could be obtained. The motions were semi-solid, green, and offensive. During the last twenty-four hours the infant had refused food.

The infant was so ill that it was difficult to decide what form of treatment was the most urgently indicated.

In order to stimulate the infant, 6 ounces of normal saline solution were injected in the tissues near the right axilla, and to this the infant made a distinct response. The gums and the necrosing patches were then gently sponged with a warm solution of boracic acid. The juice of a lemon mixed with twice the quantity of water was then given by means of a spoon, and was retained. A modified milk according to the following prescription was obtained within three hours, and the infant was fed with this by means of a spoon, as sucking was out of the question:

℞	Per Cent.
Fat - - - - -	1·50
Lactose - - - -	7·50
Whey proteids - -	0·90
Caseinogen - - -	0·15
Alkalinity - - -	10·00

Unheated. Twelve feedings, each containing 1 ounce.

The juice of one orange (or lemon) diluted with either 1 or 2 parts of water was ordered to be given every two hours, before feeding. As the infant showed marked preference for lemon-juice, this was given instead of orange-juice.

On the next day the infant seemed brighter and more conscious of its surroundings, though it still moaned a great deal; but it occasionally cried, and seemed to be suffering from pain.

The motions were normal in consistence, less offensive, but still green. The temperature was still high (102·4°), and the pulse was 120. The colour of the face was gray, the mouth seemed to be rather worse, and the odour was extremely offensive.

As the infant seemed to be suffering from sapræmia due to absorption from these putrefying surfaces, it was decided to make an attempt to remove as much of the septic material as possible.

The necrosing surfaces were scraped and were then swabbed with hot boracic solution. This little operation was not attended with any serious

bleeding, as where any hæmorrhage ensued this was controlled by pressure; but, nevertheless, the infant suffered from shock, and 6 ounces of normal saline solution were injected into the tissues of the left axilla with marked benefit. One drachm of brandy in a table-spoonful of water was given by the mouth. Half an hour after this the infant was fed. On the third day of treatment the infant showed marked signs of rallying, the pulse fell to 100 and the temperature to 99·8°. The odour from the mouth was scarcely noticeable, and the general condition was distinctly improved. It was now not satisfied with the amount at each feed, and this was increased to 2 ounces.

On April 6 the swelling of the gums was much less, but the infant was restless and cried much. During the following days a marked change took place. The crying became almost incessant. It could not bear to be touched, and the nurse experienced the greatest difficulty in attending to its requirements. The lemon-juice was now reduced, in amount, as it was thought that the large amount given might be producing these effects. But the suffering was not lessened. It was clear, having regard to the general improvement in the condition, that the infant was now suffering from the pain which had previously been in abeyance, owing to its almost unconscious condition. As it became more intelligent this feature increased, so that it showed apprehension if anyone approached its cot.

On the tenth day the gums had receded sufficiently to allow of the teeth being seen, and the swellings in the limbs were diminished, while some of the petechial hæmorrhages had disappeared and the others were much less obvious. The patch on the left thigh had completely disappeared by the fourteenth day. On the sixteenth day the first signs of deliberate voluntary movement of the limbs appeared, in the shape of movements of the hands. About forty-eight hours afterwards the infant moved its feet. From this time the progress was rapid. The signs of disease rapidly cleared up, and the gain in weight was remarkable, being in one week as much as 18 ounces. It was now able to take a milk mixture according to the following prescription:

℞	Per Cent.
Fat - - - - -	3·75
Lactose - - - -	7·00
Proteids - - - -	2·00
Alkalinity - - -	5·00

Five feedings, each containing 9 ounces.

The baby now showed distaste for lemon-juice, and would not swallow it. It, however, did not refuse orange-juice in water, and the juice of an orange was given every other day until the twenty-fifth

day, when it was discontinued. From this date progress was continuous, and at the end of the sixth week of treatment, on May 20, the last occasion on which the patient was seen by the author, it was doing well and was quite happy.

Occasionally scorbutus and rachitis are seen in the same subject at the same time. In such cases the scorbutic symptoms should first be dealt with. When these have disappeared, the rachitic condition should be treated. It is, however, remarkable that cases where both diseases are well marked in the same patient seem to be extremely rare. The diet responsible for the development of scorbutus is frequently of the character associated with the worst cases of rachitis, yet the two diseases are rarely combined in anything like the same degree. A severe case of scorbutus may show on recovery from this disease some of the signs of rachitis, but they are very slightly marked in comparison with the severity of the scorbutic symptoms. *Per contra*, it is rare to see a well-marked case of rachitis in which any of the symptoms could be ascribed with certainty to the incidence of scorbutus. It would seem that in some way the expression of dietetic defect in the one form interferes with its expression in the other form.

CHAPTER XVII

THE MORTALITY AND DISEASE OCCURRING IN INFANTS

THE present conditions of infant life throughout the country, and their effects upon the number of the population and upon the health and vigour of the community are of serious moment. The facts furnished by the Registrar-General clearly show the heavy mortality among infants. In the year 1900 the total number of registered deaths in England and Wales amounted to 587,830. The following table, the figures of which are derived from the Registrar-General's report, shows the part played by infant mortality in relation to the mortality at later ages:

TABLE SHOWING THE NUMBER OF DEATHS IN ENGLAND AND WALES, AT VARIOUS AGES, IN THE YEAR 1900.

From birth to three months	68,820
From three to six months	30,283
From six to twelve months	43,809
Total under one year	142,912
From one to two years	37,240
From two to three years	13,973
From three to four years	9,122
From four to five years	6,713
Total from one to five years	67,048
From five to twenty-five years	48,249
From twenty-five to thirty-five years	32,062
From thirty-five to forty-five years	41,288
From forty-five to fifty-five years	50,196
From fifty-five to sixty-five years	63,579
From sixty-five to seventy-five years	72,799
From seventy-five years and upwards	69,697
Total for all ages above five years	377,870

These figures demonstrate the gravity of the present situation.

The number of deaths in the first three months of life is greater than the total number of deaths occurring among children between one and five years of age. The total number of deaths among infants is nearly three times as great as the number occurring between the ages of fifty-five and sixty-five. After one year of age, the highest incidence of mortality is between the ages of sixty-five and seventy-five. The number of deaths at the ages between these limits is considerably less than one-half of the number occurring in the two years of infant life. The deaths during the first year constitute over 24 per cent. of the total number of deaths at all ages.

That this excessive mortality in infants is due to causes which are essentially preventable is recognised by every competent observer. But the mortality associated with the present condition of affairs is not the worst aspect. The physical deformities, the mental and nervous defects, in the surviving child and adult are to be seen on all sides. Mr. William Hall, M.R.C.S., in the summer of 1903, weighed, measured, and examined the limbs and teeth of 2,335 Board School children in the city of Leeds and neighbourhood. He found that more than half of these children were rachitic, and that considerably more than half had decaying or badly-developing teeth.[1] These factors of death and disease constitute a serious menace to the community.

With the view of investigating the primary causes of this mortality and disease, the author, in April, 1903, requested the Medical Officers of Health of some of the principal districts and towns to furnish him with facts within their observation and with their opinions derived from their experience. The importance of the facts and opinions to be recorded in the following pages can scarcely be exaggerated, and they are the more valuable since they

[1] Letter to the *Times*, September 1, 1903.

represent the conclusions of trained observers working quite independently in various parts of the country.

Dr. E. W. Hope, in his report on the health of the city of Liverpool for the year 1901, brought forward a series of valuable observations.

The number of deaths ascribed to zymotic diarrhœa was very large.

In the course of an inquiry into infantile mortality, 1,082 families in which the death of an infant had occurred were taken consecutively, and certain particulars concerning them ascertained. The total number of children born in these families had been 4,574, but out of that number 2,229 had died—practically all in infancy—representing 487 deaths out of every 1,000 born. The most remarkable series of excessive mortality occurred in twelve families, in which the large total of 117 infants had been born, and no less than 98 had perished in infancy. These extreme examples occurred in families in which, so far as municipal sanitation is concerned, there was very little to choose between them and many of the families who rear all, or nearly all, their children.

A careful investigation was made into the circumstances of upwards of 1,000 consecutive deaths in districts where infantile mortality was excessive. In 21 per cent. the families were described as extremely and exceptionally dirty; in 18 per cent. the mothers went out to work, leaving the infant in the custody of others, frequently in the custody of another child. About 11 per cent. of the total were living in dwellings unfit for human habitation. In upwards of 25 per cent.—and these the cases where the mortality appeared to be the highest—the parents were markedly intemperate.

The following table shows the incidence of infant mortality in Liverpool:

TABLE SHOWING THE RATE OF MORTALITY PER THOUSAND, AND THE TOTAL NUMBER OF DEATHS, AT EACH OF TWELVE AGE PERIODS DURING THE YEAR 1901 IN LIVERPOOL.

	Under 1 Year.	1 to 2.	2 to 5.	5 to 10.	10 to 20.	20 to 30.	30 to 40.	40 to 50.	50 to 60.	60 to 70.	70 to 80.	80 and upwards.	Total at all Ages.
Rate of mortality per 1,000 living at ages indicated	214·4	82·5	19·7	6·3	3·3	5·4	10·7	18·6	31·9	55·7	99·3	186·1	21·6
Total number of deaths at each age period	4089	1363	950	466	454	720	1054	1339	1512	1557	1002	373	14879

The precise circumstances of the parents in regard to their ability to provide the food and care necessary for infants are necessarily of great importance in determining the incidence of mortality. This is illustrated by the annexed table showing the contrast between the districts in which the poorer classes live and a select residential district such as Sefton Park.

VARIATIONS IN MORTALITY ACCORDING TO DISTRICTS IN LIVERPOOL.

District.	Percentage of Deaths of Children under Five Years of Age to Total Deaths.	Percentage of Deaths under One Year to Total Births.
Scotland - - - - -	45·1	22·2
Exchange - - - - -	36·4	24·1
Abercromby - - - -	33·7	15·6
Everton - - - - -	48·0	19·4
Kirkdale - - - - -	44·4	19·5
West Derby (West) - - -	45·8	17·8
Toxteth - - - - -	41·6	18·8
Walton - - - - -	48·3	15·5
West Derby (East) - - -	37·7	16·5
Wavertree - - - - -	46·2	16·5
Sefton Park - - - -	29·3	12·0

The number of deaths occurring in infants under one year of age registered in the city of Liverpool for the year 1901 was 4,138. In the table below the chief causes of death are shown.

TABLE SHOWING THE CHIEF CAUSES OF DEATHS OCCURRING IN INFANTS UNDER ONE YEAR OF AGE IN THE CITY OF LIVERPOOL.

Diarrhœa - - -	892
Cholera infantum - -	17
Atrophy - - - -	654
Gastro-enteritis - -	39
Diseases of stomach, etc. -	27
Inflammation of bowels -	160
Inflammation of stomach	54
Dentition - - - -	66
Bronchitis - - -	339
Pneumonia - - -	211
Convulsions - - -	431

These figures demonstrate the factor that is responsible for the mortality. The majority are ascribed to disorders of the alimentary tract, unquestionably arising from external sources and not from inherent debility of the infant. Other causes, such as 'convulsions' and 'dentition,' are merely the secondary or immediate causes, being incidents of malnutrition. The same may be said in regard to the deaths due to bronchitis and pneumonia. Clinical experience is sufficient to prove that by far the greatest incidence of these diseases is among infants the subjects of rachitis or general malnutrition. Diseases of the lungs are, in infants, almost invariably secondary to malnutrition.

This view is strongly confirmed when these returns are examined in order to ascertain the number of deaths due, for instance, to rachitis. Only nine cases were so certified as occurring in infants under one year of age, and only twelve cases in all for deaths under two years.

In the certifying of death, the tendency is to ascribe the death to the final symptoms determining the time and character of the death—a tendency which it is difficult for the most conscientious medical man to altogether avoid.

Since rachitis is essentially a chronic disease, the death is ascribed to the intercurrent disease rather than to the cause chiefly responsible for the origin of the intercurrent disease and, to a still greater degree, for its fatal termination. It would therefore greatly increase the value of the mortality returns if medical men, in certifying deaths, would take pains to see that the presence of malnutrition, rachitis, etc., is duly recorded on the death certificate, whether these conditions appear or do not appear to have had any immediate influence in causing the death of the infant.

In reference to zymotic diarrhœa, Dr. Hope's conclusions are as follows:

Investigation proves incontestably that the deaths of infants from this cause are closely associated with the method of feeding, putrefying food being the medium by which the specific poison is commonly introduced. The deaths amongst children under three months of age, either wholly or partially fed on artificial foods, *are fifteen times as great* as they are amongst an equal number of infants fed upon breast milk ; *i.e.*, investigation has tended to prove that, out of every 1,000 infants under three months of age naturally fed upon breast milk alone, 20 die of autumnal choleraic disease ; but if the same number of infants, at the same age, are artificially fed, then, instead of 20 dying, as many as 300 will die from this cause.

The mortality is always highest in the season of decay. If the summer and autumn are wet, it is comparatively small ; but a warm, dry season is invariably attended with a high mortality. This is illustrated by the following table :

	Period.	Average Annual Rainfall, June to September.		Annual Average of Deaths from Zymotic Diarrhœa during the Third Quarter of the Year.
	6 years	13·8 inches	average wet summers	373
	14 years	10·9 inches	average dry summers	573
Extreme years	Year 1891	16 inches	(wet summer)	203
	Year 1895	7·7 inches	(dry summer)	819
	Year 1901	8·4 inches	(dry summer)	1,067

The total number of deaths from diarrhœa were 1,269, distributed as follows :

Under one year	892
Under two years	256
Under three years	45
All other ages	76
Total	1,269

That the cause of these deaths arose from infection is proved by the great number occurring between June and September. In the Everton district, 275 deaths from diarrhœa occurred in the year ; of this number, 232

occurred in the third quarter. Out of the total shown in the above table, 1,067 occurred at this period of the year.

Dr. Alfred Hill, Medical Officer of Health for Birmingham in 1892, devoted especial attention to the part played by the various factors of insanitation, overcrowding, etc., in reference to infant mortality. Though this investigation is not of recent date, none of the factors have appreciably altered and the facts collected by him are of considerable importance.

He drew attention to the remarkable fact that the improvement in the general sanitary condition of the town during the previous nineteen years, which had had the effect of lowering the general death-rate very considerably, had resulted in no perceptible influence on the infantile death-rate. This is seen from the following figures:

Birmingham.	Infantile Death-rate (per 1,000 Births).	General Death-rate.
Average of nine years, 1873-1881 -	169	23·5
Average of ten years, 1882-1891 -	169	20·6

Thus, while there had been a reduction in the general death-rate equal to 12 per cent., the infantile death-rate showed no reduction. Had this decreased in the same proportion, the infantile mortality would have fallen to 148 per 1,000 births.

Inquiries were made as to the employment of mothers away from their homes, the suckling of the infants, and as to the part played by infant life insurance, the wards being arranged in the same order. The first table following shows the rate of mortality in the various wards, beginning with the highest rate—viz., 240 in Market Hall—and ending with the lowest rate—viz., 119 in Edgbaston. The second table shows the result of the inquiries.

TABLE SHOWING THE RATE OF MORTALITY IN THE VARIOUS WARDS OF BIRMINGHAM IN 1891.

Ward.	No. of Births in 1891.	No. of Infant Deaths in 1891.	Infant Mortality Rate per 1,000 Births, 1891.
Market Hall - -	267	64	240
St. Mary - - -	554	128	231
St. Stephen - -	878	185	211
St. Bartholomew -	1,022	205	201
Duddeston - -	921	180	195
Nechells - - -	1,204	235	195
Deritend - - -	882	161	183
Whole city - -	14,683	2,504	171
St. George - -	782	133	170
St. Martin - -	728	123	169
Ladywood - -	891	146	164
Rotton Park - -	1,305	200	153
St. Thomas - -	684	101	148
All Saints - -	1,387	194	140
St. Paul - - -	527	66	125
Bordesley - -	2,029	251	124
Edgbaston - -	472	56	119

TABLE SHOWING THE FACTS ASCERTAINED IN REGARD TO THE CIRCUMSTANCES OF THE INFANTS.

Ward.	No. of Cases inquired into.	Percentage of Cases in which—		
		Mother was employed from Home.	Infant was not suckled.	Infant's Life was insured.
Market Hall -	34	12	38	35
St. Mary - -	50	18	32	44
St. Stephen - -	94	17	35	49
St. Bartholomew -	88	19	27	30
Duddeston - -	78	12	21	33
Nechells - -	92	11	34	43
Deritend - -	95	16	41	41
Whole city - -	1,222	13	39	36
St. George - -	60	13	40	65
St. Martin - -	55	18	40	24
Ladywood - -	106	8	61	26
Rotton Park -	114	14	41	33
St. Thomas - -	38	5	50	24
All Saints - -	107	10	40	37
St. Paul - -	35	11	23	31
Bordesley - -	152	11	38	29
Edgbaston - -	24	0	58	8

A systematic examination of the sanitary conditions of the homes connected with this infant mortality was carried out—1,937 houses were examined, and the conditions were tabulated :

TABLE SHOWING THE CONDITION OF HOUSES IN REGARD TO SANITATION.

Wards.	Number of Houses examined.	Percentage of Houses having—								
		Front Ventilation only.	Only Three Rooms or Less.	No Cellar.	Partially-paved Yards.	Ashpit Privies.	Pan Privies.	Water-Closets.	Closets too near House or in Bad Condition.	Nuisance from Closets, Drains, Animals, etc.
Market Hall	53	49	64	23	36	9	68	28	9	19
St. Mary	96	65	76	30	29	9	74	19	15	36
St. Stephen	151	65	68	32	37	12	63	25	15	17
St. Bartholomew	105	66	66	53	41	6	77	18	14	30
Duddeston	146	50	49	25	75	4	68	29	7	9
Nechells	207	46	48	40	71	5	63	32	15	17
Deritend	135	60	62	41	45	14	65	24	17	27
Whole city	1,937	55	58	32	49	11	65	25	13	19
St. George	116	69	78	14	37	21	64	18	14	21
St. Martin	98	77	80	31	48	3	65	35	18	35
Ladywood	136	66	66	24	4	10	67	24	1	7
Rotton Park	172	49	56	30	70	15	57	29	10	5
St. Thomas	38	71	66	32	66	8	63	29	11	11
All Saints	177	47	51	20	58	11	72	19	18	9
St. Paul	52	73	79	19	52	17	54	29	17	29
Bordesley	227	32	31	47	41	15	62	22	16	27
Edgbaston	28	46	54	11	75	7	36	57	7	4

In Dr. Hill's words, only one conclusion can be drawn from the above figures : It is that the sanitary conditions to which attention was directed could not be shown to have had any evident connection with the infantile mortality. Thus, looking at the first of the columns of percentages, it is seen that the five wards, St. George, St. Martin, Ladywood, St. Thomas, and St. Paul, in which the largest proportion of houses examined had ventilation at the front only—a most undesirable condition—had each of them a lower infantile death-rate than the city as a whole. Two of the wards with higher

infantile death-rates—Duddeston and Nechells—had lower percentages of very small houses than the whole city. The proportion of houses without cellars, or with partially-paved yards, showed no relation whatever to the death-rate in infants. No special preponderance of any particular form of closet accommodation was found in either of the two classes of wards designated as healthy and unhealthy, and the existence of nuisances on the premises was not in a very marked degree more noticeable in the unhealthy than in the healthy wards.

Dr. Hill added that the information obtained indicated that external sanitary conditions appeared to have no marked influence on the rate of mortality at this period of life, and that the methods of infant feeding constitute the factor chiefly responsible for the persistence of the high mortality.

The next inquiry was in reference to the causes of death, and the figures here quoted again show the part played by defects of nutrition :

INFANT MORTALITY IN BIRMINGHAM IN 1891 FROM DIFFERENT DISEASES.

Deaths from—	Number registered.		Number inquired into.	
Premature birth	268		129	
Diarrhœa and dysentery	245		128	
Stomach diseases	51		13	
Enteritis	67		37	
Tabes mesenterica	33		21	
Convulsions	127		64	
Teething	38	1,072	21	505
Want of breast milk, starvation	22		5	
Debility, atrophy, inanition, marasmus	48		216	
Suffocation	107		51	
Bronchitis	389		201	
Pneumonia	126		65	
Whooping-cough	115		60	
Measles	27		18	
Other causes	400		193	
Total	2,504		1,222	

The Liverpool statistics for 1901 are in agreement with these. The factors are those associated with diseases of the alimentary tract. Next to these, the greatest factor is bronchitis. Dr. Hill here referred to a striking fact. If exposure to cold were the great cause of these deaths from lung diseases, we should expect to find the mortality high where the temperature was generally low. In Norway the rate of infant mortality was at this time 106, and in the Faröe Islands only 86, per 1,000 births, whereas in Iceland the infantile death-rate was 295. In Norway mothers universally suckle their own children. In Iceland this is rarely the case.

Dr. Hill's summary of his observations was as follows:

'The improper feeding of children is practically slow starvation. It is the cause, in some cases, of the death of all the children of a family, and frequently of the greater proportion of them. Privation of breast milk and improper feeding are not only answerable for infantile sickness and death, but their effects are seen in after-life in imperfect development and inferior physique.'

Mr. Edward Sergeant, Medical Officer of Health for the County of Lancaster, in his report for the year 1901 wrote as follows:

'The high infant mortality in some of the districts indicates that much has yet to be accomplished before this disgrace to civilization is removed. A death-rate of 200 out of every 1,000 children born was attained in sixteen districts during the year under report.

'The return from the various districts showed an enormous increase of infantile mortality during the third quarter of the year, when the temperature of the soil at a depth of 4 feet reached 56° F., or higher. Sixty-six per cent. of the total deaths occurred in August and September, the precise figures being as recorded in the annexed table:

TABLE SHOWING NUMBER OF INFANTILE DEATHS IN THE FOUR QUARTERS OF THE YEAR.

First Quarter.		Second Quarter.		Third Quarter.		Fourth Quarter.	
January - -	15	April - -	19	July - -	286	October -	105
February -	17	May - - -	20	August -	730	November	27
March - -	28	June - - -	32	September	395	December	17
	60		71		1411		149

'The number of deaths registered in the administrative county during 1901 was 29,782. Of these, 7,848 infants died before reaching the age of one year—*i.e.*, close upon a quarter of the death-rate was contributed from this source.'

Mr. William Berry, Medical Officer of Health for Wigan, found on inquiry that in nine out of every ten cases of zymotic diarrhœa the child had been brought up on an artificial diet, and was chiefly bottle-fed. Between July 1, 1900, and September 31, 1901, there were 115 deaths from diarrhœa in infants below one and a half years of age. Of these, 78 were bottle-fed, 5 were bottle and breast fed, 18 were breast-fed, and 2 were spoon-fed.

Mr. W. Naylor Barlow, Medical Officer of Health for Bootle, has reported on the factors of infant mortality in that borough.

He stated that a glance at the causes of death showed at once the cause of the high infant mortality. Diarrhœa accounted for 43 per cent. of the total deaths. Inquiries into the manner in which the children who died were fed showed that, of 46 who died under one year of age, 9 were fed on the breast alone, 30 on new or condensed milk in long-tubed bottles, 6 on new milk in boat-shaped bottles, and 1 was fed on 'anything.' The two most striking points were: (1) The small number of sanitary defects found to exist—or, in other words, the slight influence which municipal sanitation had on the deaths

from diarrhœa during the outbreak; (2) the improper feeding.

In thirty-three houses long-tubed bottles were used, in spite of repeated personal warnings and instruction by leaflets, etc., and in almost every case the lady sanitary inspector found the milk in the bottles sour. Condensed skimmed milk was largely used in the feeding.

Dr. Alfred Greenwood, in his report for Crewe, stated that he was convinced that the solution of the problem of infantile mortality lies in the careful regulation of infant feeding, together with strict attention to the cleanliness of houses and yards. During the year 1901, one-third of the total number of deaths occurred among children under one year of age. His later investigations in the methods of feeding at Blackburn have strongly confirmed these conclusions.

Dr. Charles Dingle, Medical Officer of Health for Middlesbrough, concluded that improper feeding has very much to do with the high infantile death-rate, and cited several cases illustrating the inadequate foods given to young infants. He is of opinion that in many cases this is not so much due to ignorance on the part of the mothers as to laziness.

The influence of the method of feeding is again shown by the figures of Mr. C. H. Tattersall in reference to Salford:

	No. of Births.	Deaths.	Death-rate per 1,000.
Fed on breast alone - - -	374	39	104
Breast milk with cow's milk or other food - - -	65	10	154
Cow's milk - - - -	30	12	400
Other foods - - - -	25	11	440
Total - -	494	72	

Dr. J. C. Thresh, Medical Officer of Health for the County of Essex, in 1902 arranged a conference of certain of the Medical Officers of Health in the county to discuss the question of infantile mortality.

He stated that the death-rate per 1,000 of infants under one year of age was in West Ham 202, in the extra-Metropolitan towns 147, and in rural districts 95. In this county alone about 1,000 infants died each year whose lives ought to and could be saved. Not only, however, could these lives be saved, but the same measures would tend to make the others stronger. They would become from the outset better able to fight the battle of life, and increased physical strength would tend to a corresponding increase in mental and moral strength and to a general all-round improvement.

Dr. Nash, of Southend, had observed that the improper disposal of dust and refuse had a great deal to do with the mortality of infants. Flies bred on these heaps of refuse, and later contaminated the food supplied to the infants.

Dr. Fenton had found that the infantile mortality in Barking in the summer months was as great as 402 per 1,000. Overcrowding did not seem to play an important part in this matter in Barking. Out of 186 deaths, 146 were due to improper feeding.

Dr. John Robertson, in his report for Sheffield, draws attention to the same factor. His report deserves especial attention, as he recommends punitive measures in certain cases.

Unless some effective measures of dealing with obstinate negligence are provided, it is scarcely likely that any serious diminution in the present mortality and disease will be obtained. There can be little question that the adherence to traditional methods is largely responsible for the present conditions, and unless measures of a more or less punitive character are adopted, one of the most

powerful factors will remain untouched. The best method of dealing with this aspect of the question will be discussed later.

Dr. Robertson's report is as follows:

'Like other towns with a large artisan class, the infantile mortality in Sheffield is a high one.

'During the year 1901 no less than 2,573 deaths occurred among children who had, at the time of their deaths, not reached one year of age. This gives an infant mortality-rate of 202 per 1,000 births.

'In previous years the corresponding rates were:

1892 - - -	167	1897 - - -	197
1893 - - -	193	1898 - - -	195
1894 - - -	157	1899 - - -	194
1895 - - -	195	1900 - - -	200
1896 - - -	171	1901 - - -	202

'The infantile mortality-rate varies considerably in the different districts of the city, as is shown in the following table:

West - -	207	Park - -	224	Nether Hallam	195
North - -	250	Brightside -	201	Upper Hallam	156
South - -	185	Attercliffe -	222	Ecclesall -	166

'The rate for Sheffield during 1901 was a very high one compared with that in previous years, and also when compared with the rates during 1901 in other towns whose populations may be fairly compared with that of Sheffield.'

'About half the deaths that occur in Sheffield are of children under five years of age, yet of the total population at the census one out of every eight persons living was under five years of age.

'Whatever be the cause of the increase in the death-rate among young children, the actual cause is, without doubt, carelessness or ignorance in the rearing of infants. This fact has been dwelt on in several previous reports. The remedy largely resolves itself into four lines of action: (*a*) Improving the milk-supply, so that it is delivered to the consumer in as clean a condition as we demand that our water should be delivered; (*b*) improving the sanitary surroundings of the dwellings of the people; (*c*) educational measures; and (*d*) punitive measures for those who endanger the lives of young infants by carelessness in feeding and rearing.'

Dr. Meredith Young, Medical Officer of Health for Stockport, has summarized the chief factors responsible for the excessive infant mortality in this town, and an abstract of his report is appended:

The chief causes of this high death-rate amongst infants is maternal ignorance and neglect finding its effect in early weaning, injudicious hand feeding, and lack of proper care in the general management of infants. Another and a large contributing cause is the employment of female labour in factories, leading in many cases to premature confinement, and the death of the immature infant thus born.

The following figures, giving the causes of death in infants during 1902, appear to confirm these opinions:

	Deaths.
Diarrhœal diseases	46
Inflammation of stomach or intestines	41
Atrophy, debility, wasting	88
Premature birth	50
Debility at birth	16
Dentition	29
Convulsions	35
Acute bronchitis	45
Broncho-pneumonia	24
Tubercular diseases	21
Whooping-cough	20
Nineteen other causes	62
Total	477

As in most other matters connected with the public health, the greatest evil of all is the ignorance which prevails amongst, not merely the poorer classes, but to an almost equal extent in the classes which one would expect to find educated in matters connected with the hygiene of infancy. Such ignorance dies hard, and it is only with the very greatest difficulty that we can break down and supplant the old-established and harmful notions which are rooted in the minds of both old and young mothers. The young mothers are almost invariably found the more rational and amenable to suggestion and correction.

The system of employing well-educated ladies to visit mothers at their homes, and instruct them by demonstration and verbally in the feeding and general management of infants, should be the means of preventing a very great and an increasing number of deaths in young infants. For the prevention of those deaths due to premature labour

we must look again to education, but more so still to legislation. The employment of female labour in factories should be restricted in such a manner as to prevent women continuing at their work, as they frequently do, until a few days before their confinement.

In many towns efforts have been made to stem the tide of mortality and disease by 'education,' by leaflets, circulars, etc. The proper instruction of those having charge of infants is undoubtedly most important, but these instructions are practically useless unless the necessary food for the infant can be readily obtained.

At the present time it is a practical impossibility for the poor mother to obtain for her infant the food essential to health or to normal development. In regard to this, the facts relative to the character of cow's milk as generally supplied, and to the modifications necessary to render cow's milk suitable to the infant, are of the first importance.

The rule-of-thumb methods which are supposed to more or less provide for this necessary adaptation frequently fail under circumstances where the infant has every care and attention. The fact that these milk-and-water mixtures are advocated as a means of meeting the difficulties largely explains the high mortality and the frequent use of the artificial foods. The inadequacy of these traditional methods is demonstrated both by the practical results and by physiological considerations.

The mere dilution of cow's milk can do nothing to meet the necessities of the case. The proportions of fat, lactose, whey proteids, caseinogen, etc., require delicate adjustment. It is surely unreasonable to expect that the imitation of a natural product should be so easy that any mother or nurse can carry out the necessary procedures.

The great danger of the present situation is that almost everyone is looking for 'simple' methods—that is, methods which will enable any intelligent mother to prepare a suitable food for her infant from the materials ordinarily available.

Under present conditions this is quite impracticable. To inform a poor mother that all she has to do is to obtain a 16 per cent. cream, a fat-free milk, a solution of lactose, etc., and to accurately blend these under certain strict precautions, is a form of irony scarcely to be recommended.

There is another consideration of equally practical importance. It is, of course, possible to assess the average composition of the infant's natural food. It is altogether unscientific to dictate to the infant that it should correspond with a purely theoretical standard. As a matter of fact, we are not even agreed as to what should be regarded as the average standard, for averages depend on the collocation of individual analyses. That mixture which forms an ideal food for one infant may be altogether unsuitable to another. This factor is so important that attempts to formulate stock mixtures as generally suitable for infants must necessarily end in partial or complete failure.

In the attempt to counteract, as far as possible, the effects of the present conditions, some municipal bodies have undertaken the supply of so-called 'humanized' milk that has been sterilized prior to delivery. This departure is to be welcomed, as showing that the necessity for radical changes is being, to some extent, appreciated, and the Medical Officers of Health who are chiefly responsible are to be congratulated upon the spirit of progress they have shown.

But milk mixtures prepared according to set formulæ, and then sterilized, afford an extremely incomplete solution of the problem. They may do something to prevent the effects of severe infection as they occur in the summer months; they can do nothing to prevent the injury to general health and development. Milk that has been sterilized has been deprived of constituents essential to

the vitality of the infant. Not only is health and development interfered with when the infant is fed on sterilized milk, but definite disease in the shape of scorbutus is quite commonly seen as a result of this method of feeding.

The problem is a serious and difficult one. It is probably capable of solution if the authorities concerned are prepared to adopt measures which are based on a recognition of the essential factors.

The provision for the needs of the infant must be of such a character that no parent can have any reasonable excuse for failing to observe the necessary rules and precautions, or for failing to provide the infant with suitable food.

When the necessary instruction and the suitable food are readily available, stringent measures should be adopted in regard to the perverse parent.

And here the members of the medical profession have an important duty to perform. In the city of Liverpool (according to the report of Dr. E. W. Hope, already referred to) only *one* inquest was held in 1901 on an infant that had died as the result of 'improper feeding.' Yet both the figures and the statements of Dr. Hope demonstrate this factor as the predominant cause of infant mortality. Referring specifically to the 654 cases of death from *atrophy* during the year, he remarks: 'General experience justifies the assumption that the atrophy owed its origin in a very large proportion of cases to want of proper feeding.'

The refusal of a death certificate in all cases where there is evidence that the death is primarily due to the wilful neglect of adequate precautions in regard to feeding would appear to be not only a valuable service to the community but also a legal duty.

No responsible medical man would consider himself justified in granting a certificate of death in a case of

arsenical poisoning by excluding the primary cause, and merely mentioning the symptoms vomiting and diarrhœa, when he was in possession of evidence pointing to the cause. It appears to the author that these cases of 'improper feeding' belong essentially to the same category. If the coroners co-operated with the medical profession in regard to this matter, it is probable that the results would be extremely beneficial.

The publicity of the inquest, the investigation of the character of the food supplied, and the general character of the inquiry, would tend to arouse in the public mind a sense of the grave issues involved and would almost certainly bring home to the classes chiefly concerned a sense of their responsibility, which could not be so forcibly conveyed in any other way. Punitive measures of a more severe character should be employed in cases of wilful neglect.[1] But to attempt to punish or to hold up to public scorn poor parents who have not provided their infants with the necessary food when, practically, it is beyond their power to obtain such food, would be singularly unjust.

Many of the Medical Officers of Health have referred to the instruction, the leaflets, circulars, etc., issued by them. These represent the efforts of men striving against an almost insuperable opposition. But little can be expected of such efforts when pitted against those of the capitalist whose business it is to delude the ignorant.

[1] An inquest was held at Tottenham (September 11, 1903) on the body of an infant, four months old, the daughter of a painter. The mother stated that she fed the baby on biscuits, fried fish, stew, and broth, with dumplings cut up in it, and bread-and-butter, and it was ravenously fond of lumps of fat as big as the coroner's inkstand. Dr. Millar stated that death was due to gastro-enteritis, caused by improper feeding. The jury returned a verdict in accordance with the evidence, and censured the mother. This affords an instance of the class of case requiring severer measures than are at present in force.

A tradesman may be prosecuted for substituting margarine for butter, for selling a milk containing less than 3 per cent. of fat; but it is open to any individual to mix together some flour and sugar and to sell the mixture as the best food for infants and as a perfect substitute for human milk.

It is difficult to understand on what principles the present system is based. The system that leaves every citizen, however ignorant or incapable, at the mercy of every fraudulent person is logical, if otherwise indefensible. But the legal enactments have been so designed that, while certain fraudulent practices are penalized, other practices, equally if not more fraudulent, are freely permitted.

The practical result of this peculiar arrangement is that the fraudulent but non-penalized practices receive an implicit guarantee from the Government. The educated citizen acquainted with the somewhat devious facts may be able to protect himself. It is unreasonable to suppose that the ignorant citizen can do the same. So long as this unsatisfactory condition exists, it is probable that all attempts to reduce infantile mortality and disease will be greatly hindered.

No measures are at all likely to succeed unless they include an organization capable of dealing with the serious and complicated situation. Hospitals for the treatment of diseases of nutrition in infants need to be established in every large town or district. Not only would these institutions, when properly managed, do much to directly check the disease and mortality, but their indirect influence would be extremely valuable.

The hospital in each district would serve as the centre of an organization, which should be arranged so as to include every important factor. While there should be one hospital, there should be crèches in great number dis-

tributed throughout the area, so that infants who cannot be adequately fed or cared for in their own homes may be provided for. Some such provision to meet the present conditions is essential. The facts above recorded leave no room for doubt that the poor mother working in a factory cannot secure for her infant the necessary care and attention. Systematic visitation and inspection of infants by suitable persons, carried out in a manner calculated to evoke the sympathetic assistance of the parents and relatives, would be an important part of the organization.[1] The provision of pure cow's milk, with laboratories for its modification, together with arrangements for its daily distribution, would appear to be of the first importance. Unless the agencies above described have at hand the means of providing adequate food for the infants, it is, of course, impossible that their efforts can be attended with any real success.

The precise character of the arrangements would probably be dictated in each district by local considerations. In one district it might be found desirable for the organization to include every detail, from the production of the whole milk to the delivery of modified milk. In another it might be found more convenient to arrange for the supply of milk, or for its modification, or for its distribution, by contract. These matters and many others are considerations of detail necessarily varying in each case.

The organization necessary to adequately deal with the existing conditions is therefore somewhat elaborate. Not

[1] The Health Department in New York City has made arrangements for a record of all infants born in the city. A card index is made containing the names of all infants, with the name and address of its parents. The index includes all infants, whether their parents be rich or poor. Attached to the department is a body of workers whose business it is to investigate and tabulate the condition of the infants (*vide British Medical Journal*, August 22, 1903).

without some reason, in face of the present apathy and ignorance in connection with this subject, it may be said that such elaboration is altogether impracticable.

Whether it is practicable or not largely depends upon the attitude adopted by the municipalities concerned. But the facts clearly show that unless the essential factors are adequately recognised no serious improvement can be expected. It is therefore highly impracticable to recommend measures which fall short of what is required and are essentially inadequate.

INDEX

THE END.

Baillière, Tindall and Cox, 8, *Henrietta Street, Covent Garden.*